A PRODUCTIVITY AUDIT SYSTEM FOR CONSTRUCTION MANAGEMENT IN INDONESIA

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A PRODUCTIVITY AUDIT SYSTEM FOR CONSTRUCTION MANAGEMENT IN INDONESIA

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Signature..

Date....27th March 1996...........................

DEDICATED TO

1. MY FAMILY
2. UNIVERSITY OF ATMA JAYA YOGYAKARTA
3. CONSTRUCTION INDUSTRY OF INDONESIA
4. THE LORD GOD ALMIGHTY

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ABSTRACT

The aim of this research is to develop an audit system (a diagnostic and advisory system) for construction productivity improvement in the Indonesian construction industry. The development of the productivity audit system covered five stages:

1 identification of the characteristics of the construction industry in the country through literature reviews;
2 prioritization of construction industry problems by the main industry participants;
3 investigation of factors influencing productivity through craftsmen, foremen, and project managers;
4 identification and prioritization of factors for improving on-site productivity; and
5 development of a computerised system for diagnosing and providing advice for improving on-site productivity.

A preliminary study was conducted to identify some characteristics of the Indonesian construction industry such as size, organisation, procurement methods and human resource issues. Problems confronting the industry were then identified through a survey of major industry participants who are conversant with structural issues. It was conclusively found that human resource development issues predominate and must be addressed for any meaningful development of the industry. The prime movers all agree that the priority in addressing the human resource problem should be the enhancement of their productivity through training and motivational strategies.

The main human resource groups (craftsmen, foremen, and project managers) were then surveyed through structured questionnaire supported by interviews, to identify their productivity related problems, skill and motivation. The productivity problems identified by the workers were compared with results of activity sampling. Lack of material, rework, absenteeism, and crew interference are the major productivity problems faced by the three groups of workers.

A comparative study of productivity problems in seven regions in the country provided indices in terms of the craftsmen production output, working time spent productively, craftsmen skill, motivation and remuneration, as well as supervision competencies of foremen.

The priority and relative indices of the factors that predominantly influence on-site productivity were used to develop a productivity audit system for construction management in Indonesia. After diagnosing productivity problems by asking productivity related question the system proceeds to a consultation session that provides suggestion and best practices for improving construction productivity.

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LIST OF ABBREVIATIONS

ADB	Asian Development Bank
AKI	Association of Indonesian Contractors (large contractors)
ARCOM	Association of Researchers in Construction Management
ASCE	American Society of Civil Engineers
BPS	Construction Industry Bureau
BSI	British Standard Institution
CI	Construction Industry
CICE	Construction Industry Cost Effectiveness
CII	Construction Industry Institute
CIDB	Construction Industry Development Board
CIDA	Construction Industry Development Agency
CIOB	Chartered Institute of Building
CIRIA	Construction Industry Research and Information Association
CMC	Construction Management Centre
CONPAS	Construction Productivity Audit System
CPM	Critical Path Method
CSA	Constructor Support Agency
DC	Developing Country
ECI	European Construction Institute
EPC	Engineering Procurement and Construction
ESRC	Economic & Social Research Council
EPSRC	Engineering & Physical Sciences Research Council
FIDIC	Federation Internationale des Ingenieurs Conseils (International Federation of Contracting Engineers)
GDP	Gross Domestics Product
GAPENSI	The National Association of Indonesian Contractors (Small to medium contractors)

ILO	International Labour Organisation
INKINDO	The Association of Indonesian Construction Consultants
IPTN	The State Owned Aeroplane Industry
ISO	International Standard Organisation
ITB	Bandung Institute of Technology
JAMSOTEK	An insurance scheme for accident prevention
JCT	Joint Contracts Tribunal
KBS	Knowledge Base System
MPW	Ministry of Public Work
NEDO	National Economic Development Office
P	Probability
PM	Project Managers
PT	Public Company Limited
PUSBINLAT	Centre for Foremen Training
SD	Standard Deviation
SOC	Span of Control
SPSS	Statistical Package for Social Sciences
R_s	Coefficient of Correlation
R^2	Coefficient of Determination / Goodness of Fit
RP	Rupiah (£1.00 = Rp.3500,00 in 1995)
W	Kendall Concordance Coefficient
WB	World Bank

CHAPTER 1

CHAPTER 1

GENERAL INTRODUCTION

1.1 Introduction to Subject Matter

Construction productivity improvement is a dominant issue in construction management; promising efficient usage of resources and cost savings. Productivity began to catch the attention of the construction industry after the devastation of the second World War. Since then, many articles on construction productivity have been published in journals and several text books written on the subjects, in the United States, e.g. Borcherding (1975); Borcherding and Oglesby (1975); Adrian and Boyer (1976); Arditi (1985); Oglesby at. al. (1989); and in the United Kingdom, e.g. Harris (1979); Drewin (1982); Harris, et.al (1985); Price (1986); Olomolaiye (1988). Unfortunately, those investigations in construction productivity were almost entirely conducted in developed countries, with only a few from developing countries (see Olomolaiye et.al., 1987; Parker, et.al. 1987; Olomolaiye and Ogunlana, 1989a). Although not specifically for construction, the International Labour Organisation (ILO) has continuously promoted productivity improvement in most sectors of industry for both developed and developing countries (see ILO, 1979; Prokopenko, J. 1987; Heap, 1989).

Indonesia is developing towards a newly industrialised country with the economy growing at an annual rate of 7% in the last five years (Barclays, 1993). As part of its overall industrial strategy, the country began the second phase of a twenty five year development programme involving the provision of building and infrastructures such as transport, electricity and water, all being essential for an expanding manufacturing base. To achieve this development successfully, there is need for cost effectiveness in the management of the construction process. In other terms, the country needs to improve productivity in constructing its infrastructure, housing, and commercial buildings.

Although Indonesia became independent from the Dutch on 17th August 1945, it has been struggling with political and economical problems for more than 20 years. However, since 1966 the country has enjoyed steady political stability and economic growth brought by revenues from oil exploration. Despite the collapse of the world prices of oil in the mid 1980s, the economy has successfully diversified into manufacturing based, and the country has continued enjoy economic growth.

Being a developing country, Indonesia has the ambition of becoming industrialised, where foreign investment is encouraged and actively sought. With inflows of foreign investment into the country, the construction industry has benefited with foreign construction firms following investors into the country. To attract more investment, the Indonesian Government would need to continue supporting infrastructural development.

Although the construction industry is yet to be recognised by the Government as a major player in the overall national economy, its role in supporting the economy is being recognised by industry at large. Logically, an increase in investment in other sectors will increase the volume of construction output. The boom in construction works over the last 5 years witnessed this phenomenon, which is the result of increasing investment in both private and public sectors.

In spite of the impressive performance of the Indonesian construction industry over the past few years, the construction sectors is perceived as a low-productivity sector, mainly because of its low technology image and its employment of a large number of unskilled workers. Critical infrastructural development have so far been led by foreign construction firms who have experienced project managers and the technology for large projects. The liberal economic policies from the Government provide little benefit to indigenous construction firms if the foreign firms continuously dominate the industry. The

Government has realised this problem, and in the new 25-year development programme (April 1994) emphasises human resource development for all sectors of economy.

To respond to this challenge, the indigenous construction industry has to be equipped with adequate management skills. Although they have the initial competitive advantage in terms of understanding the business environment in the country, it does not take a long time for foreign contractors to learn these. Contractors in Indonesia would need to be continuously trained to improve both technology and management skills through a systematic approach.

Research and development in construction productivity by academics in developed countries have so far been largely disseminated through technical reports, articles in journals or conference proceedings. These traditional ways for academic researchers to advance knowledge have been reasonably successful. Nevertheless, managers who desire to use this knowledge in order to evaluate and improve productivity on construction sites must still read through volumes of technical reports to get the recommendations or suggestion of best practices or they must find journal articles which may not be in the company home office library, much less at the job sites.

Recognising the need for more convenient means of communicating knowledge of productivity to construction managers in developing countries, particularly in Indonesia, the findings of this research will be incorporated into an interactive computerised productivity audit system which is capable of being both a predictive and a consultative system for construction managers, as well as being used as a training tool for young construction managers.

1.2 Objectives of the Investigation:

The research aimed at developing a computerised audit system (a diagnostic and advisory system) for construction productivity improvement in the Indonesian construction industry. The development of the productivity audit system covered five stages:

1 identification of the characteristics of the construction industry in the country determined by literature review;

2 prioritization of the construction industry problems by its main participants;

3 investigation of factors influencing productivity through craftsmen, foremen, and project managers;

4 identification of factors for improving construction productivity; and

5 development of a productivity audit system based on the factors identified in (1) to (4).

1.3 Methodology

This research arose out of a perceived need to understand and evaluate construction productivity in Indonesia. The overall efficiency of the construction industry in meeting building and infrastructural needs of the growing Indonesian economy is the fulcrum of this research carried out in the following stages (see Figure 1.1):

1. A critical evaluation of the development of the Indonesian construction industry in a historical context. A literature review was conducted to trace the critical junctures in this development. Historical outputs of the industry were analysed to detect any trends. Literature on the development of construction industry in other developing and newly industrialised countries were surveyed for comparison; to determine if there are common patterns in the development of construction industry world-wide.

2. Problems of the construction industry were investigated through its major participants. Priority of the problems in a strategic drive for solutions were determined.

3. Factors influencing construction productivity in Indonesia were identified. To achieve this, four sets of structured questionnaires were developed targeting construction operatives, site supervisors / foremen, site managers, and experts respectively. The questionnaires were patterned after the Michigan Organisation Assessment Package with each productivity factor quantified. The construct validity of the questionnaire were tested through pilot postal survey before conducting main surveys in Indonesia. Results were analysed to detect the underlying productivity problems and the relative importance of the factors. Adopting the work sampling technique (BSI, 1985) the levels of utilisation of the working day by all project participants were quantified. Results of this analysis were correlated with the questionnaire responses to enable a full appreciation of the productivity problems as the basis for developing of a productivity audit system.

4. Identification of factors for improving productivity were identified through project managers and experts, using a structured questionnaire augmented with interviews. Factors for improving productivity were identified from construction literature and grouped into four categories: (1) Method and technology, (2) Site management, (3) Working environment, and (4) Human factors. The relative importance of the factors in each of these categories were identified. The priority of factors for improving productivity were compared between project managers and experts.

5 Based on the findings of (3) and (4), factor influencing productivity were applied for diagnosing 'on-site' productivity problems. Factors that are potentially capable of improving productivity were applied for advising project managers on the best approach to improving productivity on Indonesian construction sites.

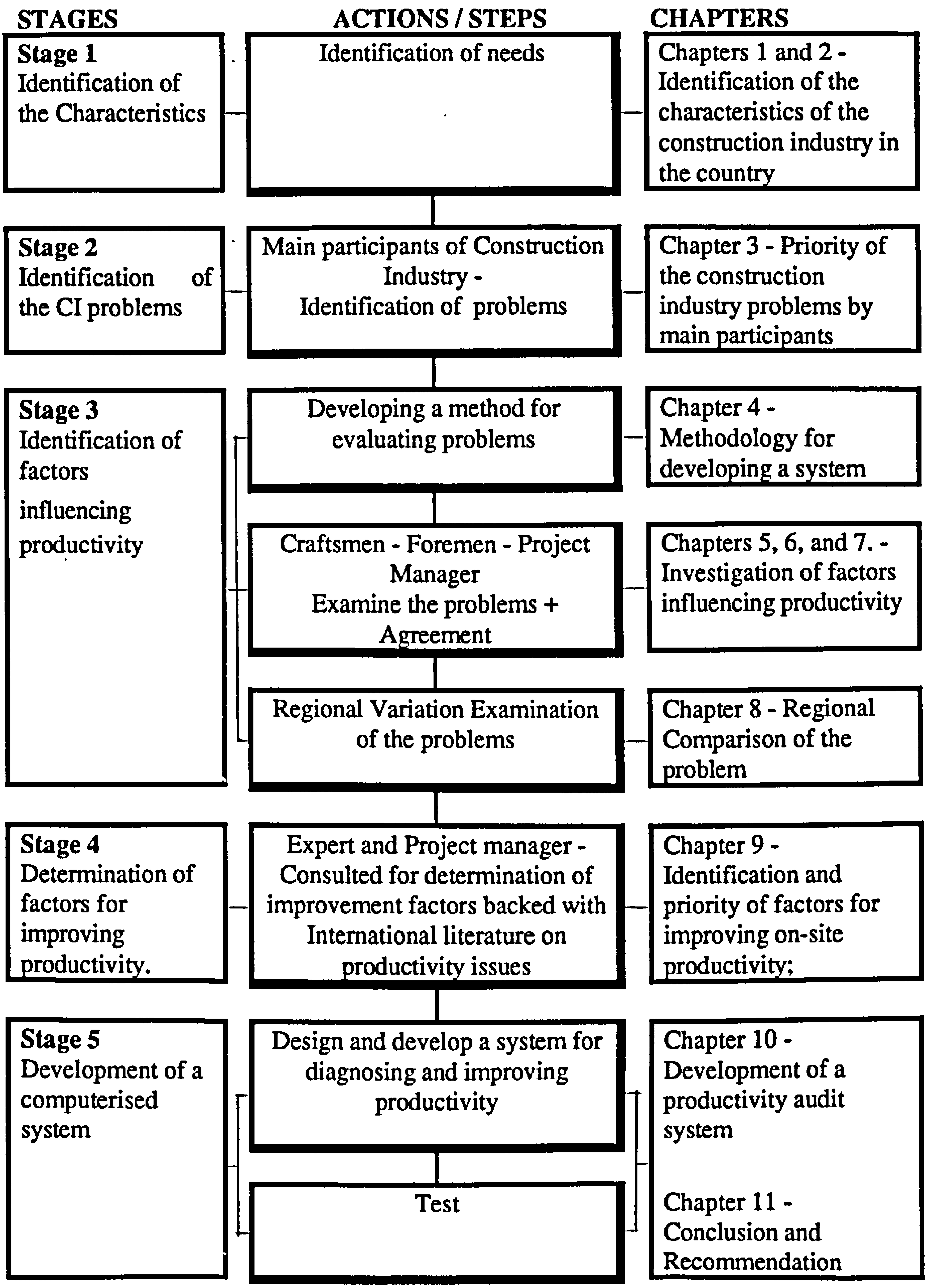

Figure 1.1 Research Methodology

1.4 Organisation of the Thesis

Chapter 2 - describes the nature of the Indonesian construction industry; its size, its contribution to the national economy, its main participants and their organisations, process and products of the industry including procurement methods, sources of its human resource and education for construction.

Chapter 3 - identifies the main problems facing the construction industry of Indonesia through a study of strategic development issues, which examined other countries' experience and successful approaches applied to solve these problems in other developing countries. Under-development of the human resource was found to be the most severe problem.

Chapter 4 - explains the hypothesis and constructs of research instruments based on literature review in the preceding chapters. Having found that under-development of human resource is the most severe problem facing the Indonesian construction industry, the main groups of site personnel working at construction sites (craftsmen, foremen, and project managers) were investigated through a set structured questionnaires supported by interviews. The questionnaire design, sample selection and surveys are all described in this chapter. The techniques used for data analysis are briefly discussed.

Chapter 5 - reports findings of the craftsmen questionnaire survey with regard to their perception of productivity problems on their sites. Their characteristics including age, experience, training and educational background are reported. The productivity problems identified by the workers and results of activity sampling are also discussed.

Chapter 6 - reports findings of the foremen questionnaire survey with regards to their perception of productivity problems on their sites. Their characteristics including time spent in various activities are compared with those from other countries. The productivity problems as identified by the foremen are compared with those identified by craftsmen.

Chapter 7 - reports investigation of productivity problems through the project manager questionnaire survey. Results are compared with those identified by craftsmen and foremen.

Chapter 8 - reports a comparative study of productivity problems in the seven regions of Indonesia. Results generate indices for the regions in terms of craftsmen production outputs, working time spent productively, craftsmen skill, motivation and remuneration, as well as level of supervision of foremen, their motivation, and remuneration.

Chapter 9 - reports an investigation of factors for improving on site productivity. Results provide the priority ranking of the factors that predominantly influence on-site productivity. Impact of these factors on resource utilisation was also investigated and discussed through comparison of results obtained from project managers and experts. The relative importance indices of these factors form the basis of the productivity audit system for diagnosing and improving on-site productivity

Chapter 10 - reports the design of the productivity audit system using expert system technology. The reason for selecting the development tools used for creating the system is briefly described. It then reports the knowledge elicitation process, followed by system design which includes model, system interface, output, technique, how the system is used, and testing / validation of the system.

Chapter 11 concludes the results obtained from this study and provide some fundamental information related to construction industry problems.

CHAPTER 2

CHAPTER 2
THE INDONESIAN CONSTRUCTION INDUSTRY IN PERSPECTIVE

2.1 Introduction

This chapter reports the role and importance of the construction industry to the Indonesian economy. The industry's size and structure are introduced, procurement methods commonly adopted in the industry are described, and currently available construction management techniques and tools highlighted. The market for construction and relevant issues in human resources development including its characteristics, composition, and availability are also discussed. The chapter concludes with a suggestion for improving the performance of the industry especially through the establishment of an Indonesian Construction Development Board.

Indonesia, geographically shown in Figure 1.1, occupies more than 14000 islands with a total land area of 1,919,443 square km, and is located in South East Asia, between Asia and Australia. It has a population of 189.1 million, of which about 60% live in the relatively well developed Java island which is only 6% of the total land area. Most industries are located in Java and consequently most infrastructural developments. The government's economic priority since the 1960s has been geared towards stabilisation, in particular the reduction of inflation which was around 600% per annum in 1965 and 1966, and the restructuring of government finances through the rehabilitation of the productive base of the economy, with greater encouragement given to the operation of a market economy (see Papanecks, 1980; Dixon, 1991; and Barclay, 1993). Foreign investment has been encouraged and foreign aid actively sought.

It is generally acknowledged that the government has achieved these broad objectives and the First 25-Year National Development which ended in 1994 is regarded as an indicator of the progress made in national development. The Indonesian economy has continued to enjoy vibrant growth. Economic growth of about 8% was recorded annually between 1970 - 1980 largely due to general increase in global oil prices (Indonesia is an oil exporting country), see Wawn (1982). The economic base has also been successfully diversified with growth stabilising at 8.3% and 7.3% in 1993 and 1994 respectively (President Soeharto's Annual Report on 17th August 1995). Sunday Business (21th April, 1996) reported the growth of Indonesian GDP of over 8% in 1995.

From the sectorial distribution of GDP illustrated in Table 2.1 Construction contributes 5.3% of the GDP which is relatively low in comparison to Agriculture and Manufacturing. However, the sector grew at 9.2% in 1994 considerably higher than the 6% rate at which the whole economy grew over the same period (see CIDB, 1994). Business News (1992) indicating that from 1986 to 1990, the size of the Indonesian construction industry actually doubled (see Figure 2.2). By 1991 the value of work in the industry was 21.3 trillion rupiah, gradually increasing to 22.3 trillion rupiah (trillion = 10^{12}) in 1992. In fact, the industry has been enjoying an unprecedented boom since the beginning of the 1990s (see Wibisono, 1994a).

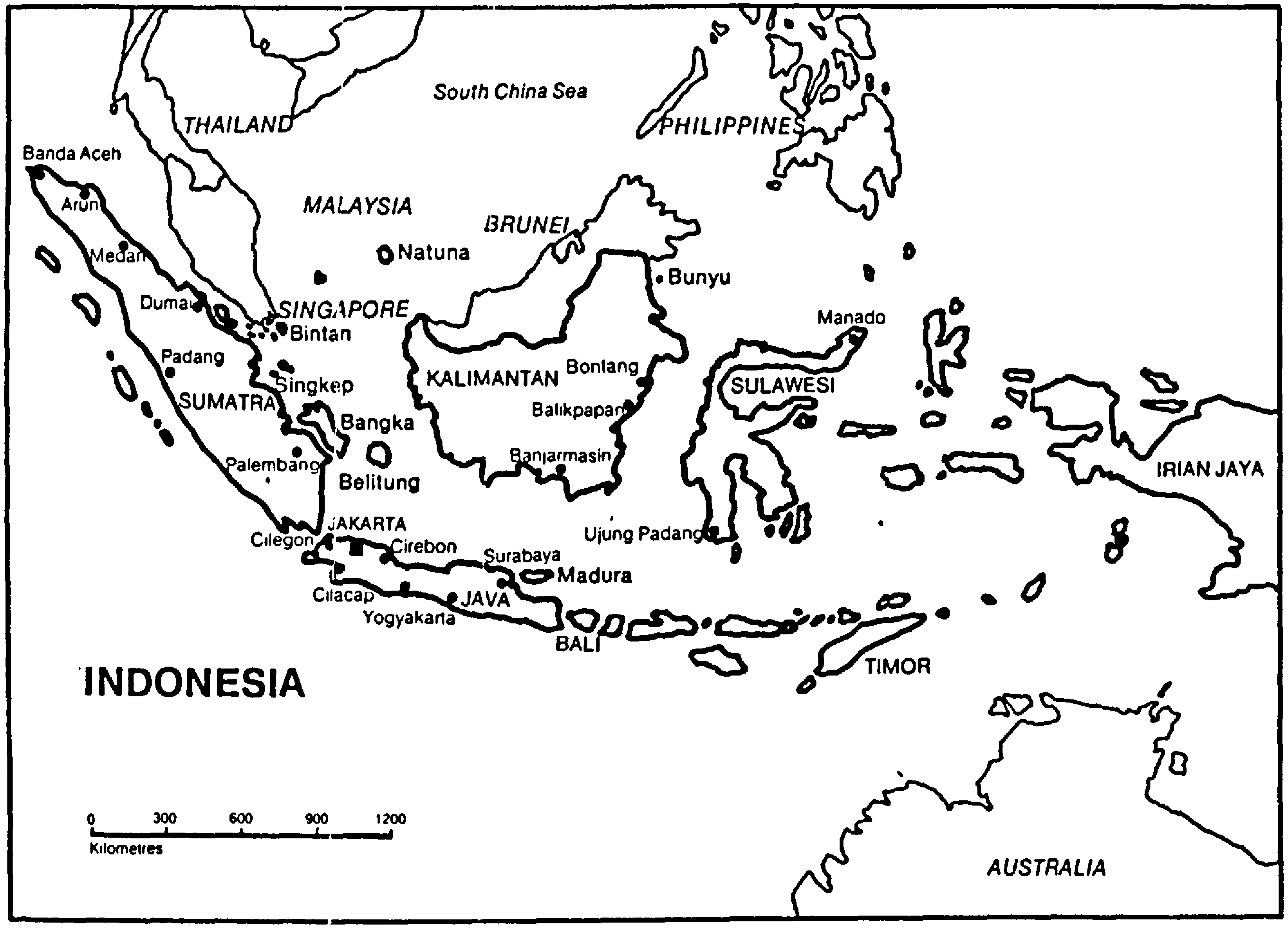

Figure 2.1 Republic of Indonesia

Table 2.1 Percentage Distribution of Indonesia GDP at 1983 Constant Prices.

Industrial Origin	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**
1. Agriculture	22.89	22.29	22.68	21.98	21.40	21.18	20.58	19.44	18.50
2. Mining and Quarrying	20.75	20.62	18.19	18.10	17.31	15.90	15.53	15.19	15.60
3. Manufacturing industries	12.75	14.55	15.79	16.29	17.18	18.19	18.48	19.35	19.90
4. Electricity, Gas & Water supply	0.40	0.39	0.42	0.48	0.52	0.55	0.57	0.63	0.70
5. Construction	5.92	5.29	5.30	5.12	5.08	5.26	5.48	5.80	6.00
6. Wholesales & Retail trade	14.17	14.22	14.57	14.87	15.19	15.67	16.05	16.13	15.94
7. Transportation & Communication	5.28	5.35	5.27	5.18	5.22	5.21	5.28	5.53	5.60
8. Banking & other financial intermediaries	3.04	3.41	3.55	3.87	3.87	3.75	4.00	4.25	4.50
9. Ownership of dwellings	3.03	2.90	2.89	2.83	2.81	2.76	2.68	2.60	2.54
10. Public Administration & defence	7.36	7.22	7.59	7.62	7.79	7.94	7.82	7.63	7.36
11. Services	3.87	3.75	3.74	3.66	3.62	3.57	3.46	3.46	3.42
Gross Domestic Product	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Gross Domestic Product *(excluding Oil and Gas)	**77.67**	**83.04**	**85.08**	**90.08**	**94.52**	**99.89**	**107.44**	**115.11**	**122.71**
Actual GDP*	**77.67**	**89.89**	**97.00**	**102.68**	**124.82**	**142.11**	**167.18**	**195.60**	**225.99**

Source : Central Bureau of Statistics, Indonesia. * in trillion rupiah.

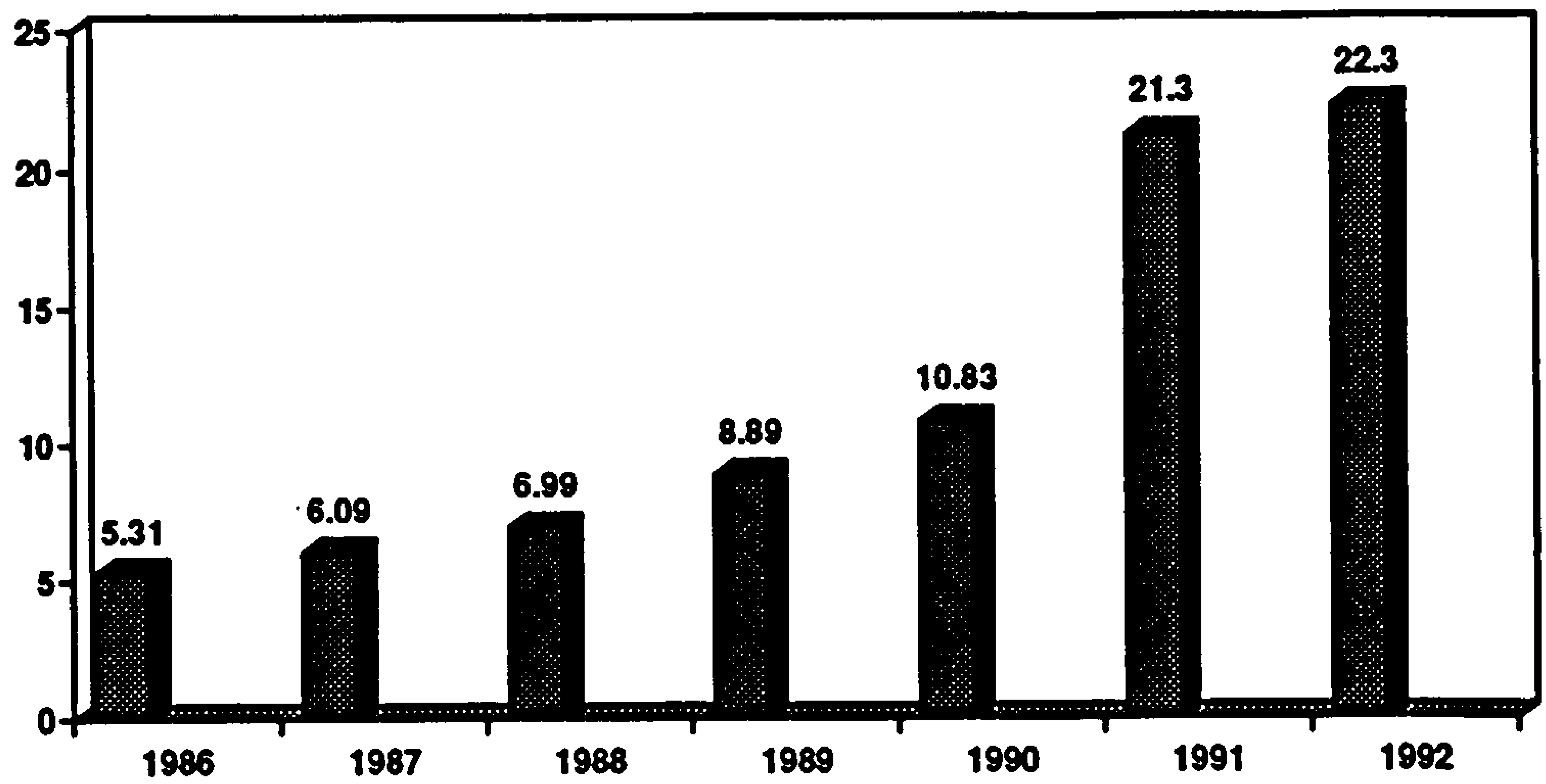

Figure 2.2 The size of the Construction Industry in Indonesia Between 1986 -1992. (in trillion rupiah) Note: US $ 1.00 = Rp 2200.00 in 1994
(Source: Business News, 17th-6-1992 and Information Business Data Centre, 1994)

2.2 Organisation of the Indonesian Construction Industry

The construction industry in both developed and developing countries is characterised by a pyramid structure, with a few large companies at the top and many smaller ones at the bottom. Figures from *GAPENSI* (The National Association of Indonesian Contractors) indicate that of the 32,718 construction companies in Indonesia 27% can be classified large with the rest small to medium sizes (Annon., 1994d). As in other countries, the large companies execute a high percentage of the total amount of work in financial terms, but not necessarily in terms of number of projects. The gap between large and small firms in Indonesian is even wider in terms of turnover, resources, access to inputs, operating environment and future prospects. The larger companies are mostly foreign firms working in the country temporarily on large technological complexes, or on joint ventures between foreign and state-owned firms, joint ventures between foreign and local private companies, or private firms owned by groups of conglomerates or state-owned firms (Stallworthy, et.al. 1985). The smaller companies are usually local with limited operations in a particular region. Regardless of size, any company wishing to bid for a public facility contract, must be registered and classified on the basis of several criteria set by the Ministry of Public Work (MPW).

The Indonesian contractors that are large and well established are state owned and have interests in a wide array of construction activities. One of the largest National companies, PT Jaya Konstruksi Manggala Pratama, is part of the Jaya Group with construction business ranging from housing, entertainment facilities, and high-rise building to construction management services. Other state owned companies such as PT Hutama Karya, PT Nindya Karya, PT Waskita Karya are also involved in building and civil engineering construction. PT Wijaya Karya is another large contractor with the highest turnover in the last three years and business interests spanning both civil engineering, building and other related construction business having an estimated turnover in 1994 of about 470 billion rupiah (Indonesian monetary unit is Rupiah (Rp), for 1994, US$1 = Rp. 2200). In addition, there are specialist companies which are State owned e.g. PT Pembangunan Perumahan and PT Brantas Abi Praja. Well established private contractors include PT Total Bangun Persada, PT Bangun Tjipta Sarana. PT Nusa Raya Cipta, PT Decorient Indonesia, PT Wijaya Kusuma Contractor, PT Dimensi, and PT Murinda. Most large contractors are members of AKI (Indonesian Contractor Association), a contractor organisation similar to GAPENSI, but mainly for large contractors.

INKINDO - The Association of Indonesian Construction Consultants is the umbrella organisation for all consultants of which only 38% of its 4500 members are professionally qualified (Wibisono, 1994a). They mostly have their headquarters in Jakarta with operational offices in the regions. There are several well-established consulting engineering firms operating in the country, for example: PT Encona Industries Inc. (EII) which provide services such as feasibility studies, project planning, design and engineering, project management, construction management, construction supervision, and start up & commissioning; Wiratman & Associates which specialises in designing high-rise building. Others are Jaya Construction Management Manggala Pratama, widely known as Jaya CM, a sister company of Jaya Group providing construction management services; PT Tripanoto Sri, Kiat Karsindo Consultants, Dacrea, and Atelier-6.

The Indonesian construction sector is mostly non union. However, labour strikes in other industries tend to be on the increase (see Wibisono, 1994c) . For instance, there were 177 strikes, with an estimated 590,000 man-hours lost in 1992; an increase of 36% over the previous year. The importance of safety to the construction worker is emphasised by Indonesian safety regulation. However, contractors do not face bankruptcy or go on trial when accidents occur on site.

2.2.1 The Market for Construction

Since the 1970s, the Indonesian construction sector has benefited greatly from the investment boom and economic growth which has created demand for utilities and services. (see Table 2.2). Construction output by type of work reflects the composition of the Indonesian Construction Market. Infrastructure and improvements to roads and bridges dominate the market at 33.8%; sectorially, Civil Engineering projects contribute about 60% of the entire construction output (see Langdon, 1994). While these are 1990 figures, the picture has remained generally the same although the non-residential market - i.e., factories and offices, is enjoying more growth because of continued emphasis on manufacturing.

From the Government's projection and World Bank staff estimate (see Table 2.3) it would seem the emphasis on infrastructural development would continue. Since large investments are involved the Government expects more participation from the Private sector. The projection to spend US$ 52.3 bn. (= Rp.115.0 trillion) on infrastructural development over the next 5 years seems optimistic but shows the direction of Government and World Bank thoughts on developing the country (World Bank, 1994a).

It is recognised that as a developing country, the scope of the Construction Industry and it's output are not as well defined as in developed ones (Hillebrandt, 1985); as such the figures in Tables 2.1, 2.2 and 2.3 may not reflect all construction activities but can be seen as being a reasonable picture of construction activities.

Table 2.2 Indonesian Construction Output by Type of Work, 1990.

Category	Type of work	Percentage of value of total output completed
Building	Residential	5.9
	Non residential	28.8
	Mixed type of building	0.5
	Specialist work related mainly to building	7.5
	Subtotal Building	**42.7**
Civil Engineering	Water supply	1.9
	Electricity supply & network	3.5
	Construction or improvement of roads/bridges	33.8
	Irrigation/drainage	10.3
	Airport, harbours, bus station, etc	2.4
	Other	5.3
	Subtotal Civil Engineering	**57.2**

Source: David Langdon & Seah International 1994.

Table 2.3 Indicative Infrastructure Investment Programme by Sector and Public / Private Participation (Percent shares in total infrastructure investment).

	Public Sector		Private Sector		Total	
	89/90-93/94	94/95-98/99	89/90-93/94	94/95-98/99	89/90-93/94	94/95-98/99
Power	35.4	36.4	9.8	34.5	29.6	35.7
(% of GDP)	(2.0)	(2.1)	(0.2)	(1.0)	(2.2)	(3.1)
Telecommunication	9.8	11.6	6.5	6.9	9.0	10.0
(% of GDP)	(0.5)	(0.7)	(0.1)	(0.2)	(0.2)	(0.9)
Transport *	42.7	39.0	77.2	51.7	50.5	43.3
(% of GDP)	(2.4)	(2.3)	(1.2)	(1.5)	(3.6)	(0.2)
Irrigation	6.1	3.2	-	-	4.8	2.1
(% of GDP)	(0.3)	(0.1)			(0.3)	0.2)
Water resource Mgmt	2.9	2.4	-	-	2.2	1.6
(% of GDP)	(0.1)	(0.4)			(0.1)	(0.1)
Urban Water & Sanitation	3.1	7.4	6.5	6.9	3.9	7.3
(% of GDP)	(0.2)	(0.4)	(0.1)	(0.2)	(0.3)	(0.6)
Total	100.0	100.0	100.0	100.0	100.0	100.0
(% of GDP)	(5.5)	(5.8)	(1.6)	(2.9)	(7.1)	(8.7)
Total Investment in Rp. Trillion (1989/90 prices)	52.2	73.0-77.0	15.3	37.0-38.0	67.5	110.0-115.0

Note: * Includes investment in fixed as well as non-fixed public transport infrastructure facilities. The bulk of private investment in non-fixed transport services(e.g. commercial trucks, bus, ships and aircraft), although a rising proportion will go towards fixed facilities in the future (e.g. toll-road, port, etc).

Source: Government Five Year Development Plan and World Bank staff estimate (World Bank, 1994a)

2.2.2 Government as the Major Client

As in most developing countries the need for infrastructure to underpin economic growth often leads to the Government being the dominant client for the construction industry. In Indonesia the rapid growth in manufacturing has led to the need for the Government to take a lead in infrastructure developments. Currently Government projects include Olefin plant at Cilacap, Centre of Java, owned by Pertamina, and Shell & Partners costing around US$1,500 million, (expected duration 1990-1994), Jakarta outer ring road owned by PT Jasa Marga with the cost US$824 million and expected duration period 1991-1996. Batam industrial park, an island near Singapore, owned by PT Batamindo Investment Corporation, with the cost US$500 million, and expected duration period 1990-1994. Jakarta harbour road, owned by PT Citra Lamtoro Gung Persada, cost US$350 million with the expected duration period 1991-1996. (See Tiong & Yeo, 1993).

2.2.3 Private Clients

The sign of an emerging middle class is confirmed by new apartments, housing and real estate businesses. There has been a high demand for dwellings by young couples, and a mushrooming of condominium developments in Jakarta. In August 1993, a property development company, the Bakrie Group, offered nearly 2400 new apartments for sale in Jakarta's fashionable Kuningan business district at prices ranging from US$60,000-115,000. These were sold out in a week! More recently, the company has put another 1,938 units on sale at a higher average price of US$116,000.

The leading players in property development and real estate in Indonesia are respectively: 1. Ciputra Development, 2 Dharmala Intiland, 3. Duta Anggada, 4. Jaya Real Property, 5. Lippo Land development, 6. Metro Supermarket, 7. Modern Land Realty, 8. Pakuwon Jati, 9. Panca Wiratama Sakti, 10. Plaza Indonesia, 11. Pudjiadi and Sons E., 12. Putra Surya Perkasa, and 13 Summarecon Agung. In addition to these thirteen main players, 60 public corporations are involved in various forms of property development ranging from housing, apartments/condominiums, shopping centres, golf courses, office developments, etc. (see Wibisono, 1994c).

2.2.4 Procurement Practices

There are four procurement methods in Indonesian construction: Traditional engineering procurement and construction method (EPC), Turnkey, Design and Build (DB), and Construction Management Services (CM).

Traditional EPC Procurement Method - The traditional EPC method is mostly employed by the Government Department Ministry of Public Work (MPW). The first step of the EPC tendering procedure on Government projects is the invitation of selected candidate contractors, or interested candidates with appropriate qualifications. Participants have to buy the drawings and specification in order to be able to quantify the volume of works. The second step is the government / owner setting a forum to explain the details or answer any queries about the drawings with further specifications supplied at this forum. The third step is the tender with only a single criteria: the lowest bidding price being rewarded. The winning bidder has to agree to standard contract documents which specify a certain value of a guaranteed deposit to be placed in bank in order to be sure that the contractor is financially stable. Payment of the contractor is usually arranged into 5 periods with respect to the progress / value of the work done. The first payment is received when the contractor has executed at least 25% of the works. The second 25% of contract value is paid when 50% of the works have been completed. The third payment value is 25%, and the fourth payment is 20% when 100% of the works have finished. The remaining 5% is retained for a maintenance period, usually of month.

Turnkey Method - Most Indonesian contractors do not operate or get involved in turnkey projects generally because of the large capital outlay required. However, this procurement method is typically employed on some public utility projects as 'Build

Operate and Transfer' schemes on highway construction and electricity power supply projects.

<u>Design and Build Method</u> - Most housing projects in the private sector employ this method. It is considered simple, flexible and easily understood by the population and in fact an extension of the traditional Indonesian builder and client relationship. Goodwill is very important for projects under this procurement method as more often than not the owners/clients request design changes at the construction phase. Recent development of the Golf Course Village at the Kemajoran Airport in Jakarta employed this procurement method.

<u>Construction/Project Management Service</u> - Rather at its infancy, some state and private companies procure their projects via CM. For instance, IPTN (The State Owned Aeroplane Industry) employed Jaya Construction Management Service to develop their high-tech and complex facilities. More international construction engineering and management consultancies are now taking advantage of new investment schames for foreigners, to establish themselves in Indonesia. The CM method looks set to become even more established.

2.3 Contractor Qualification and Operating Environment

2.3.1 Contractor Pre-Qualification.

The Ministry of Public Works (MPW) employs a contractor classification system to control the nature and size of the projects a contractor may be allowed to bid for, and issues a contracting license and technical proficiency certificate. There are six classes of contractors based on past experience, technical and management capability, financial status, and other resource availability, ranging from the highest Class A, though B2, B1, C3, and C2, with C1 being the lowest. A contractor can renew or upgrade his classification based on the pre-qualification criteria. Similarly to contractor classification, consultant firms have to be registered with the MPW if they expect to provide services to the Public sector. There are 61,305 national contractors and 3,521 consultant firms registered with MPW (Wibisono, 1994a and Annon. 1994f). See Table 4.

Table 2.4 Major contractors and consultants registered in MPW in Java Island*.

Java Island	**Contractors**		**Consultants**	
Regions	**number**	**%**	**number**	**%**
DKI Jakarta	10,261	31.6	1,397	56.0
West of Java	9,521	29.4	603	24.1
Centre of Java	5,354	16.6	179	7.2
Yogyakarta	1,250	3.9	80	3.2
East of Java	5,947	18.4	237	9.5
Total	32,328	100	2,496	100

Source: Pusbinlat MPW.

2.3.2 Project Control

Construction management is the application of management techniques to control time, cost and quality. With regard to achieving these goals, the tools widely used by Indonesian contractor for planning, scheduling, and control of construction projects are Bar Charts and Critical Path Method (see Antill & Woodhead, 1989). Cost data is maintained by each company for estimating bid price. Unlike in the UK, there is neither a standard method of measurement nor a standard quantity take off code available. Whilst there are currently no standard forms of contract like JCT and FIDIC, the Indonesian Chamber of Commerce together with GAPENSI, and INKINDO are currently developing an Indonesian contract form (See Pribadi & Langford, 1995).

For Project Management, contractors employ some sophisticated software packages such as Artemis, Primavera, Harvard Project Management, and Super Project.

2.3.3 The Operating Environment

There are seven main difficulties related to the Indonesian construction operating environment:

1. Fluctuations in the total workload of the industry, as well as those of individual firms. Indonesian public sector investment in the construction cycle is varied to suit prevailing requirements in the management of the economy. Currently the commercial development sector is in decline because the Government has adopted structural adjustment programmes under World Bank guidance, and is no longer investing in commercial properties.
2. Variations in construction output caused by geographical and unbalanced development differentials between regions; currently most infrastructural development are concentrated in Java and Bali.
3. Frequent shortages of materials, components, plant and equipment, and spare parts. This is worst in many isolated areas due to shipping and transportation problems. In some remote areas such as South Kalimantan, the price of building materials can be twice that in Java (Annon, 1994b). Recently the price of cement jumped by 50% reflecting material shortages problem. (Annon, 1994c and Kwik, 1994).
4. Adoption of inappropriate building regulations and codes of practice. Indonesia, like many developing countries has not conducted research to determine appropriate building codes. Indonesian graduates from overseas Institutions have brought back the codes of the country in which they have studied and assumed they will be appropriate for Indonesia. There is therefore a variety of building codes from different industrialised countries (especially from the United States, United Kingdom, and Japan).
5. Inappropriate contract documentation and procedure. The terms and conditions of the forms of contract which require contractors to have performance bonds, in the interests of their clients whose payment processing procedure is very bureaucratic, are

absurd. The worst scenario is when a contractor is still owed by the client after the building has been completed.

6. Sheer number of contractors in the industry. During the oil boom era the Government made it a priority to license more small contractors. These companies now sell their facilities to others especially those with good contacts with public clients in a practice known as 'pinjam nama' i.e. ('borrow the company label'). Large companies who have large facilities but no contracts may sell their facilities to small ones who are favoured by Government Departments' adherence to an income re-distribution policy.
7. Like many sectors of the economy, construction faces a scarcity of skilled workers. Formal training schemes are inadequate, and informal on-the-job training arrangements are not well-developed. Contractors are reluctant to invest in training their workers as they can be poached by others. The tendency for contracting firms to adopt casual employment practices is not helpful to the development of an indigenous skilled labour force.

2.3.4 The Construction Workforce

In Indonesia, the construction industry is not considered as important as either manufacturing or agriculture. Table 2.5 shows the percentage distribution of the total labour force over the main sectors of the economy from 1980 to 1990. Note that construction has not been separately identified in the survey by the Department of Manpower (Cobbe & Boediono, 1992). Proportion of informal sector (self employment) in construction in 1980 and 1990 were 32.80% and 25.93% respectively (see Evers and Mehmet, 1994).

Table 2.5 Percentage distribution of working labour force in the main sectors in Indonesia.

Sectors	1980	1982	1985	1986	1987	1988	1989	1990
1. Agriculture	55.9	54.7	54.7	55.1	55.0	55.8	56.2	49.2
2. Manufacturing	9.1	10.4	9.3	8.2	8.3	8.6	10.0	11.4
3. Trade	13.0	14.8	15.0	14.3	14.9	14.2	14.8	14.7
4. Social Services	13.9	12.3	13.3	14.7	15.9	15.4	12.6	14.2
5. Others (including construction)	8.2	7.8	7.8	7.8	6.0	5.9	6.3	10.5

Source: Department of Man Power, *Profil Sumber Daya Manusia Indonesia*, Jakarta 1990.

Compared with other South East Asian Countries, wage levels are low in Indonesia (see Davis, et.al., 1988; Annon, 1994g). There is also little or no job security as workers can easily be fired and hired. This may be understood from a background of a largely unskilled workforce which is primarily made up of peasant farmers. Most of these workers come to construction from farms, simply to augment their income while waiting for harvest time, with minimum of skill and knowledge of construction work.

Absenteeism is often a major problem with workers absent in some instances for funerals or marriage ceremonies or other traditional events back at the village. All these reflect on their overall construction productivity; it is difficult training someone who will be on the farm next week!

Technical staff include site agents, technicians, draughts men and equipment maintenance workers, who have some kind of formal or informal education. Large companies employ them as permanent staff.

Most construction managers have degrees and some project management experience. Designations include: Financial Manager, Marketing Manager, Procurement Manager, and Technical Administration and Equipment Manager. Estimators and Project Schedulers with computing knowledge are the best paid middle managers in Indonesian construction companies.

2.3.5 Contractors' Management Style

Local construction companies in Indonesia are mostly under sole ownership, headed by entrepreneurs with limited experience in construction and often with other business interests. The firms are therefore somewhat transient. Furthermore, they are unable or unwilling to employ qualified personnel. The proprietors are also reluctant to delegate responsibility to others, especially where this involves monetary transactions such as the purchasing of materials.

Owing to Indonesian cultural background, the proprietors of construction firms, both Private and State, and as in other sectors of the economy, have a paternalistic and highly personal management style. Private companies still prefer to employ members of their own family or people of a certain trait from a particular region, especially in more senior positions. In state owned firms there seems to be a strong 'old boy' network with management often preferring to employ graduates of the Institutes or Universities they themselves graduated from.

2.3.6 Construction Education and Training

Education for construction exists at three levels to meet the industry's needs. The first level is for operatives who attend basic technical schools for 6 years. It consists of a 3-year intermediate operatives' schools (*Sekolah Teknik*), and another 3-years for the intermediate technical school (*Sekolah Teknik Menengah*). The second level is for technicians with diplomas awarded at colleges known as *AKADEMI*. The third level is for middle managers, who are educated at Universities or Institutes.

There are two major divisions of engineering and technology departments in most State Universities which meet the needs of the construction industry. Most of the Institutions have divisions of Civil Engineering and Architecture. These two divisions produce the construction, design and management professionals. The latest trend for the professional manager in Indonesia is to acquire a post graduate management training. Some private schools in Jakarta are now establishing Professional Masters Degrees in Construction Management.

While the Ministry of Public Works has encouraged graduate and post graduate degree programmes in construction, there has been a shortage of staff to teach on these programmes. To overcome this shortage, Ministry of Public Works and Institute of Technology Bandung are in co-operation with the University of New South Wales in Australia and the University College London to train construction education staff.

Another step in this direction is the establishment of the Construction Industry Bureau, known as *Biro Bina Sarana Perusahaan* (BSP) with the assistance of the World Bank based on a detailed study by consultants in 1981. BSP established the Construction Management Centre (CMC) with the following objectives:

1. To ensure that all graduates entering the industry have received an introduction to the management of the construction process at undergraduate level.
2. To undertake research projects in construction management of special interest to BSP or MPW.
3. To assist the development of short training courses, seminars and teaching aids.
4. To develop a post graduate course in construction management. MPW also set up *PUSBINLAT*, a foreman training centre with technical assistance from ILO (see Andrews, 1987 and Mile & Neale, 1991).

Semi skilled and unskilled employees make up the majority of construction workers. Some operatives are apprenticed for work experience but do not have formal education. Craftsmanship is maintained through one generation passing skill on to the next. Traditional craftsmen live close to the great Borobudur Temple which their ancestors built in the late 400s AD.

2.4 Construction Development Programmes

Efforts have been made in Indonesia to improve the performance of construction firms, generally as part of the post-independent effort to create a sizeable, efficient and effective national construction industry as well as an attempt to create local privately owned enterprises in commercial and industrial sectors of the economy. It can be argued that the construction industry development in Indonesia has so far concentrated on the development of contracting firms, and that the solutions to problems in the industry are only reacting to the obvious deficiencies of the firms when compared with their counterparts in industrialised countries. Initial efforts included admonitions that small companies should merge, and that contractors should manage their firms more professionally by delegating some responsibilities, and seek technical and/or managerial training or employ qualified personnel. State owned banks were urged to give contractors loans and material suppliers urged to offer them better trading terms.

The development of the Indonesian Construction Industry has often been characterised by various forms of protection for locally owned firms. Tendering preferences on public projects with a joint venture or joint operation between indigenous and foreign firms is given priority on the assumption of technological transfer from foreign to indigenous firms. There has not been any scientific evaluation of this assumption; experiences in other developing countries do not fully support this assumption (Andrew, 1987). It is generally difficult to make joint ventures effective, where the co-operation is not voluntary and originally motivated by the commercial interests of the partners. Some specific approaches to the development of Indonesian construction industry are now discussed.

Small and medium sized contractors in Indonesia have limited access to funds as they are seldom able to offer the necessary fixed assets as collateral. Advance payments by clients are rare and interim payments are routinely delayed. Thus, construction companies in Indonesia often face severe cash flow problems. Efforts to improve contractors access to finance have taken the following forms:

1. On government projects there is a provision of an advance loan as soon as the contractor is awarded a contract.
2. The developers who are awarded the license to build could also be provided loans by State Saving Bank.

A successful model of financial aid for contractors has been successfully implemented in Ghana by the Bank for Housing and Construction (see Ofori, 1985). More commercially strong organisations e.g. financial institutions can be encouraged to enter construction business by creating 'shell' companies, acquiring a number of existing medium sized firms, going into joint ventures with such a company, or forming construction companies to undertake some of their own project initially. The privatisation of state-owned construction firms is another option that could be considered.

2.5 Summary

Following the trend in South East Asia, the Indonesian Economy has been liberalised and the country has enjoyed fairly stable economic growth in its first 25-Year National Development Plan period. Over this period the construction industry consistently contributed 5.5% of annual GDP. Because of the rapid economic development programme the construction industry has exerted itself as probably the main engine of growth of the Indonesian Economy; recording 9.31, and 11.24% of the GDP in 1992 and 1993 respectively. Despite these impressive contributions to GDP the industry still suffers from a dire shortage of skilled craftsmen and the necessary managerial competence needed to sustain the rapidly developing economy. This human resource problem is potentially the archiles heel of the Indonesia construction industry and could be possibly be addressed by developing a trade based recruitment, training and employee retention programme.

Construction industry development programmes should be formulated after studying the specific circumstances of Indonesia. The main objective should be to create a number of self reliant enterprises over a specified period of time. The programmes should be monitored and continually reviewed to maintain their appropriateness and relevance.

Efforts towards a comprehensive construction industry development should be pursued to improve contractors' operating environment. In particular there is an urgent need to review tendering and contractual procedures. The financial payment procedure should be deregulated to reduce bureaucracy and consequently improve the cash flow of contractors.

Unquestionably the construction industry can propel a developing country towards economic and technological advancement. A coherent development strategy executed/co-ordinated by a Government/Industry Agency would seem the best approach for Indonesia. Tentatively named Constructor Support Agency (CSA) or Construction Industry Development Board, such an agency (whose members would ideally include all participants in the construction industry e.g. the government, academics, contractors, consultants, manufacturers, construction specialists and state owned enterprises) could be charged with the responsibility of identifying the industry's problems, research and develop appropriate construction technology and materials, as well as co-ordinating the training for the skills needed by the industry. Specifically the agency could be charged with developing programmes such as:

- Project related finance on short terms which will either be disbursed directly by the agency or through selected banks.
- The CSA can, through a relevant insurance scheme, act to guarantee performance instead of the present practice where contractors are made to deposit some money as a performance bond.
- Provide training to members in order to maximise opportunities for successful construction through co-operation with educational or research institutions.
- Bulk purchase of key construction materials for economics scale and price stabilisation.

Targeted towards the needs of the industry, such a broad based agency could provide a more effective support than the hardly known BSP based in a government ministry.

In addition to the development of craftsmen skill, International agencies such as International Labour Organisation (ILO), Asian Development Bank (ADB), and International contractors operating in Indonesia can be expected to contribute to the industry's development. Local trades schools similar to the Henry Boot Training School in UK are recommended for Indonesia. If International contractors, possibly through the assistance of ADB could set up trades schools for their companies recruits, it would demonstrate their commitment to the development of the Indonesian construction industry which would be more beneficial than having International contractors importing their own men and equipment. Local Indonesian contractors would follow their good lead.

CHAPTER 3

CHAPTER 3

STRATEGIC DEVELOPMENT OF THE CONSTRUCTION INDUSTRY IN DEVELOPING COUNTRIES - A CASE STUDY OF INDONESIA

3.1 Introduction

Having reviewed characteristics of the Indonesian construction industry in the previous chapter, we proceed to identify problems and participants that predominantly affect the development of that industry. Indonesia is categorised as a developing country by the United Nations and related International Institutions. The term developing countries (DCs) is loosely used to describe countries which lie outside the small group of highly developed, industrialised nations. They range from countries which are large in area, varying considerably in climate and topography, to ones which are small islands. Some are located in temperate zones whereas others are in the dry and wet tropics. Many are densely populated and becoming increasingly so while others are sparsely populated. Some have well-educated and literate populations together with partially good infrastructure and facilities but others do not. Few are on the threshold of becoming newly industrialised states while several are economically backward and others are desperately poor.

The diversity indicated in the foregoing is itself made greater by a variety of political, social, psychological, cultural, linguistic, historical and religious factors. Thus, developing countries cannot be 'lumped together' as an homogeneous group but rather, should be treated on an individual or regional basis. Problems in the construction industry of developing countries can not be generalised as they are in most cases peculiar to each country's political, cultural and economic experience. To develop the construction industry (CI) in a particular country requires an identification of the problems faced by that industry, their severity and the perception of such severity in the development of appropriate policies / strategies.

The objectives of this chapter are firstly to review the problems of CI development in selected developing countries. Secondly, to present a participant based framework for strategic development of the construction industry in developing countries and apply this to Indonesia in order to identify the severity of the problems faced by the Indonesian construction industry.

3.2 Construction Industry Problems in Developing Countries

Problems identified to date include: material shortages, lack of skilled human resource, raising finance, marketing issues, low on-site productivity, and legal matters related to regulation and economy.

3.2.1 Material and Technological Problems

Material shortages and low levels of technological development in most industries, with shortages of plant/equipment, inadequate research and development (R&D) facilities and programmes, poor linkage between research and practice, and lack of development of manufacturing are the most common material and technological problems in DCs (see Imbert, 1981; Ofori, 1993). The main cause of material shortages in various developing countries is the lack of a local material development programme (Ofori, 1990). For example, despite the abundance of natural resources which can be developed as construction materials, Nigeria still suffers shortages (Wahab, 1984; Okpala and Aniekwu, 1993). Similarly, in Algeria Abdelhalim & Duff (1991) found that construction firms' complained at the difficulty of acquiring construction materials. In addition, there are other significant constraints: delivery times are too long, waiting lists too large, and remoteness of the supply enterprises.

As in other DCs, Indonesia is not free from these difficulties. Currently cement shortages are regular and contribute to increasingly high costs of construction. Furthermore, construction materials research has not been a priority for the industry. Although a few significant innovations in construction have been developed, e.g. the *Cakar ayam* foundation system, and *Sosro bahu* turning pile cap system, these have not been supported for wider application. Indeed, research activity is rare in both industry and academia giving credence to the commonly held view that technological development in the Indonesian construction industry is still largely in the doldrums.

3.2.2 Shortage of Skilled Human Resources

Lack of skilled construction personnel in DCs has been traced to the poor social image of construction, where self employment has led to poor job security and the shortage of talented and dedicated workers (see Imbert, 1990). Other industrial sectors have done better. Skilled labour shortages are likely to remain if the status, remuneration and job security of the construction worker is not improved.

Indonesian construction workers are mostly farmers who seasonally migrate to urban centres while waiting for harvest to augment their incomes on construction projects (see Kartini, 1991). They are mostly unskilled labour and readily accept low wage employment inadvertently contributing to the low esteem for construction work in the country. In addition to the poor image, Evers and Mehmed (1994) indicated that construction workforce accounted for 25.93% of self employment in the country in 1990. Whilst informality brings flexibility it also leads to lower investment in training and education of the workforce.

3.2.3 Financial Problems

Financial problems often indirectly influence time and cost overruns on projects. They are influenced by a multitude of factors including the capital base of companies, workload, payment for completed works by clients, rate of resource utilisation, prices of materials which often fluctuate and costs of machinery etc. Like in developed countries, financial institutions are reluctant to be fully committed to such high risk business.

3.2.4 Marketing Problems

The fluctuating overall level of construction activity has been considered a major marketing problem in the industry, especially in relation to resource utilization and over-head cost. During the oil boom period, DCs from OPEC enjoyed an unprecedented inflow of revenue leading to a constructor's market with abundant work for contractors. The situation has since reversed in these countries. Contractors in those countries, including Indonesia have to struggle with getting jobs in order to survive the post oil boom period.

3.2.5 Productivity Problems

Olomolaiye et.al. (1987) investigated the influence of craftsmen's productivity in Nigeria and found that only 50% of the working day was routinely utilised for productive work, the rest being spent in relaxation, waiting for tools, or materials, and taking instructions and similar delays. In practice, construction planners in Nigeria often guess final output rates and hence accurate cost estimates can not be provided.

Other examples like the Brazilian building industry categorised by Werna (1993) as being in post infancy stage still suffer from low levels of productivity, incapacity to deliver at costs affordable to the majority of the population, and low quality of products. Construction productivity in Brazil is perhaps 5 to 10 times lower than those in Japan and Europe. Such high costs are in part related to material, indeed Werna (1993) suggested that up to 28% of materials utilised on building sites are wasted due to mismanagement, and malpractice in the building process.

3.2.6 Legal issues and Politics

Complexity of procedures and regulations, delays in payments and unsuitable contract documents are commonplace (Ofori, 1991). For example, Aniekwu and Okpala (1987) on the Nigeria construction industry argued that time and cost overruns, poor quality of work, low levels of productivity (especially on projects handled by indigenous contractors) can all be partly related to legal provisions in the assigning contract. Typical of their findings are:

(i). Most DCs have a labour intensive CI, whereas contract conditions are generally designed for more capital intensive CI.

(ii). Whilst delays and cost over-runs in construction projects can be controlled by special provisions within the conditions of contract these should be designed specifically for the intended environment.

(iii). The problem of inadequate supply of skilled labour and experienced managers accentuated by the high level of unemployment prevalent in Nigeria, are some peculiar issues which the provisions in contractual arrangements do not address fully. This is probably because they are not basic to the developed countries where contractual documents were designed.

(iv). Some contractors are not aware that there are laws governing the health, safety and welfare of workers. Similarly, most workers are illiterate and do not know their rights.

Like other developing countries, the Malaysian construction industry also has problems of project time over-runs, resulting not only in cost overruns but also loss of anticipated revenue. Many government projects experience this problem with the consequence that cost can double on some projects. After a thorough investigation the Malaysian Government concluded that the problem lies in the procurement method, and consequently decided to employ turnkey procurement routes in order to share cost and time over-run risk. This met with varying degrees of success (see Yong, 1987). Construction industry problems in DCs can be broadly summarised into six areas shown in Table 3.1.

Table 3.1 Construction Industry Problems in Developing Countries.

Problem Classification	Problem Identification
1. Material shortage and Technological Problems.	- Fluctuation of the price of construction material. - High cost of material. - High cost of machinery. - High transportation and handling cost. - High machinery maintenance cost. - Inadequate production of row material in the country - Frequent shortage of construction material. - Low level of technological development in most of the industry. - Lack of R&D facilities and programmes - Poor linkage between R&D and practice.
2. Underdevelopment of Human Resource.	- Low quality of workmanship. - Poor image of construction status. - Deficiency in management level. - Inadequate skilled labour in particular of crafts. - Low pay for construction worker. - Poor industrial relation in construction. - Lack of co-ordination between designer and contractors. - Excessive bureaucracy or paper work. - Unnecessary legality. - communication problems.
3. Financial Problems	- Poor cash flow. - Mode of financing and payment for complete work. - High interest rates charged by Bank on loans. - Poor financial control on-site. - Wrong method of estimating. - Lack of capital. - Delay of budgetary allocation.
4. Marketing Problems	- Domination of CI by foreign firms. - Numerous construction going on at the same time. - Fluctuating overall level of construction activity.
5. Productivity Problems	- Improper Planning. - Frequency of design changes. - Long period between design and time of tendering. - Deficiency on-site material management - Absent of cost data in construction. - Lack of effective method of construction - Poor working environment. - Poor financial incentive programme.
6. Legal Issues and Politics	- Fraudulent and kickbacks - Poor documentation of contract management. - Lack of Government policies for construction. - Lack of legality in solving dispute. - Bureaucracy of tendering method. - Poor contractual procedures. - Unsuitable documents of contract arrangement.

3.3 Approaches to Construction Industry Development

Evidence shows that the CI has played an important role in the economy of Newly Industrialised Countries, (e.g. Singapore) and can sustain socio-economic development (Ofori, 1994). Admonishing other developing countries to follow Singapore's example he argued that most of the hypotheses on the role of construction in development would appear to be supported by the Singapore case. Ofori (1991) also identified, examined, and analysed eight possible approaches for development of the CI of DCs. These can be distilled into six basic strategies as demonstrated in Table 3.2 (see Ofori, 1991; Abdalla & Cockfield, 1984).

Having identified the main problems and strategies from literature, let us now describe a conceptual framework through which each country can identify its CI problems and prioritise strategies that would lead to development.

Table 3.2 Construction Development Strategies and Approaches.

The six strategies in this chapter	Ofori's approaches to CI development
1. Material and Technology Development Strategy.	1. Developing a comprehensive national programme for Construction Industry.
2. Human Resource Development Strategy.	2. Training and courses on tendering, construction planning, financial management, and so on.
3. Financial Aid and Cost Effectiveness Development Strategy.	3. Establish pre-financial scheme by state owned banks.
	4. Formation of shell companies.
4. Marketing Development Strategy.	5. Formation of Joint Venture from indigenous with the foreign contracting firm.
5. Productivity Improvement Strategy.	6. Establish contractor support agency.
	7. Establish Institutional support agency.
6. Legal Issues and Politics Campaign.	8. Establishes self-supporting state owned construction operation.

Note: Ofori's approaches to CI development have been summarised into 6 groups.

3.4 A Framework for Identifying Problems and Strategies

The argument underlying this framework is that while it is good to follow successful examples of Newly Industrialised Countries as suggested by Ofori (1991), the problems faced by the construction industry in each country reflects a combination of socio-economic factors requiring unique prioritising of strategies for its development. Each country should therefore identify and rank its problems and prioritise strategies for addressing them.

3.4.1 A Conceptual Framework

Six major problems namely: P1: Material Shortage and Technological Problems, P2: Under Development Human Resource, P3: Financial Problems, P4: Marketing Problems, P5: Productivity Problems, and P6: Legal issues and Politics have been identified with 6 corresponding strategies. If these problems and strategies can be ranked to generate a matrix an appropriate mix of prioritised strategies can be identified. Who should rank the problems / strategies in a developing country? The author would suggest that the main participants in the industry are most appropriate.

3.4.2 Participants in the Construction Industry Development

Eight participant groups can be identified in the construction industry namely: 1. Owners - private or public sector. 2. Designers - Architect, Engineer, Project Manager, Estimator, Scheduler, etc. 3. Contractors and subcontractors, 4. Specialists: Materials and equipment/plant suppliers. 5. Financial institutions: Banks, leasing company. 6. Authority: Government department responsible for construction industry development, 7. Training and educational institutions both formal and informal. 8. Manufacturers of construction materials. If these major participants can agree on the problems and strategies for a particular country it should form a sound basis for a Government Policy on CI development (see Figure 3.1).

	Construction Industry Problems					
	P1	P2	P3	P4	P5	P6
Owner	*					
Designer						
Contractor						
Specialists						
Banking						
Government						
Academic						
Manufacture						
	S1	S2	S3	S4	S5	S6
	Construction Industry Development Strategies					

Figure 3.1 Data analysis framework for strategic development of construction industry.
Note: * is the assignment matrix that is given by experts in terms of degree of participation of the construction participants in solving the problem ranging from 1 (low) to 10 (high participation).

3.4.3 A Case Study of Indonesia

A semi structured questionnaire was prepared and used to interview major construction participants in Indonesia. The questionnaire consisted three major parts as follows:

1. General information:

   Identity, present occupation, experience of the respondent, and years in the construction business.

2. The respondents were asked to rate the severity of the six problems identified from the literature on an ordinal scale ranging from 1 (low) to 10 (high).
3. The respondents were asked to judge the degree to which solution strategies will address the problems facing the Indonesia CI, also on a 10 point scale.

Postal questionnaire surveys are unusual in Indonesia, generally attracting a very low return rate. It was therefore decided that a semi structured survey supported by interviews with the respondents would be most effective. Participants for the survey were drawn from the main professional bodies and trades associations, and Government Ministries concerned with the Construction Industry in Indonesia. Letters requesting interviews were sent to these participants and in some cases followed up with telephone calls. From the targeted 80 potential participants, 33 were eventually successfully interviewed.

The 33 respondents covered six out of the eight identified CI participant groups. However, five of these respondents also had experience of the missing categories (Banking and Manufacturing). In all, 5 construction clients, 6 designers, 12 contractors, 1 specialists: suppliers/vendors, 6 government agencies, and 3 educational institutions were sampled.

The construction experience of the respondents varied considerably, but generally embraced a long period in at least one participant group. Indeed, including respondents with a minimum 5 years in a particular professional capacity allowed the cases to be expanded to 64. See ability gap theory (Barrett, 1992 and 1993). Table 3.3 presents the expansion of the 33 respondents to 64 cases used for analysis.

3.4.4 Case Study Analysis and Discussion of Findings

3.4.4.1 Relationship Between the Problems

Results of identification of the severity of the CI problems is shown in Table 3.4. The larger the index, the more severe the problem; indicating that under-development of human resources is the most severe problem facing the Indonesian construction industry, and financial problems the least severe. Although the result of mean rank indicated that the six problems were significantly different (sig. F.= 0.0328), it did not pinpoint where the differences are. Therefore a multiple comparison procedure using the Bonferroni method was employed (see Anderson et.al, 1993; Norusis, 1994). This method sets up more stringent criteria for declaring different significance than did the general test. Results of the analysis indicated that only the human resources problem is an independent subset, while the other five problems formed another subset. This indicates that only the human resource problem clearly proved most severe with the other five problems not significantly different from each other in severity.

Table 3.3 The Construction Industry Participants in this Study.

	The Construction Industry Participants' Experience (in years)								Total Cases
No	Owners	Designers	Contractors	Specialists	Banking	Government	Academic	Manufacture	Accounted
1	5	5	5	-	-	10	20	-	5
2	1	1	25	-	-	-	-	-	1
3	-	25	15	-	-	-	-	-	1
4	8	1	-	-	-	-	-	-	1
5	-	8	7	-	-	-	1	-	2
6	-	-	14	-	-	-	1	-	1
7	2	2	20	-	-	-	-	1	1
8	-	-	30	-	-	-	3	-	1
9	-	-	24	-	-	10	4	3	2
10	2	-	9	-	-	-	-	-	1
11	-	-	12	12	-	-	-	-	2
12	-	-	21	-	-	-	-	-	1
13	5	-	8	-	-	-	-	-	2
14	-	5	20	-	-	10	10	-	4
15	-	15	-	-	-	25	-	-	2
16	-	-	-	-	-	5	10	-	2
17	-	-	-	-	-	4	-	-	1
18	-	-	-	-	-	13	-	-	1
19	-	6	3	-	-	-	1	-	1
20	-	12	-	-	-	-	12	-	2
21	2	2	14	-	-	-	-	-	1
22	-	2	1	-	-	-	-	-	1
23	12	2	12	2	3	-	7	-	3
24	-	9	4	1	-	-	-	1	2
25	-	10	20	-	-	-	6	-	3
26	-	-	20	-	-	-	-	-	1
27	1	7	10	-	-	-	8	-	3
28	-	-	6	-	-	-	-	-	1
29	13	-	20	-	-	-	-	-	2
30	-	6	5	-	-	-	25	-	3
31	-	10	15	-	-	-	20	-	3
32	25	4	-	-	4	25	30	-	3
33	10	22	6	-	-	-	24	-	4
Total	7	13	24	1	0	8	11	0	64

Table 3.4 Ranks of the Severity of CI Problems in Indonesia

The CI Problems	Severity	Rank	Subset 1	Subset 2
Material shortage & technological problems	5.56	5		*
Under development of human resources	6.70	1	*	
Financial problems	5.61	6		*
Marketing problems	5.84	3		*
Producitivy problems	5.81	4		*
Legal issues & politics	5.92	2		*
Significance	0.0328			

Note:* indicate subset member that significantly different at 0.05 level using Multiple Comparison Procedure (Bonferroni).

3.4.4.2 Problem Oriented Analysis

Who should be made responsible for the development and implementation of particular strategies? Using Kendall concordance analysis the participants were vertically ranked according to each problem area with the highest value attributed to the group which would have most influence on the problems. For example, the Manufacturers were accorded the highest priority with a mean of 6.52, followed by Government (6.08), and Contractors (5.09) in the material shortage problem (see Table 3.5).

Participants ranked Government, Contractors and Academics 1st, 2nd, and 3rd respectively as best players in construction human resource development. They prioritised Banking, Owners and Contractors 1st, 2nd, and 3rd respectively as best to solve the financial problems of the industry, and prioritised Government, Owners, and Contractors 1st, 2nd, and 3rd respectively to indigenise the construction market. For eliminating productivity problems, the participants expected pivotal roles by Contractors, Designers, and Owners as 1st, 2nd, and 3rd respectively. Finally the main players in legal issues and political problems are Government, Owners and Contractors as 1st, 2nd, and 3rd respectively.

Table 3.5 Respondents' Perceptionon of the Role of Participants in Resolving Construction Industry Problems.

	CONSTRUCTION INDUSTRY PROBLEMS													
	Material and technological problems		Under development of human resources		Financial problems		Marketing problems		Productivity problems		Legal issues and politics		Overall	
PARTICIPANTS	mean	rank	mean	rank	mean	rank	mean	rank	mean	rank	mean	rank	total	priority
OWNERS	3.42	6	2.99	7	5.83	3	6.22	2	4.64	3	6.15	2	23	3
DESIGNERS	4.62	4	4.18	5	3.02	6	4.01	5	5.43	2	4.52	4	26	4
CONTRACTORS	5.09	3	6.29	2	5.95	2	5.83	3	7.04	1	5.83	3	14	1*
SPECIALISTS	4.61	5	5.04	4	4.16	5	3.54	6	4.56	4	3.46	5	29	5
BANKING	2.26	8	1.98	8	6.84	1	3.53	7	2.34	8	2.80	7	39	6
GOVERNMENT	6.08	2	6.33	1	5.11	4	6.35	1	4.35	5	7.16	1	14	1*
ACADEMIC	3.40	7	5.89	3	2.16	8	2.50	8	3.48	7	3.39	6	39	8
MANUFACTURES	6.52	1	3.30	6	2.93	7	4.02	4	4.16	6	2.70	8	32	7
Concordance Coeff.	0.37		0.51		0.53		0.41		0.35		0.53			
Sig. F.	.000		.000		.000		.000		.000		.000			

Note: * Joint first ranking.

To identify the participant group that should anchor the overall development of the industry, a horizontal summation of priority ranks for each participant group was performed. The results gave the total level for each participant group as 23, 26, 14, 29, 39, 14, 39, and 32 respectively. Since this summation was based on the ranking which is counted from small to large numbers, the smaller the number the more important the participant. In this case Contractors and Government were both considered the same at 14, i.e. equally expected to take the initiative in solving construction industry problems. Construction clients, Designers, Specialists, Banking, Manufacturers and Academics were considered 3rd, 4th, 5th, 6th, 7th, and 8th ranks respectively. It is worth noting that the industry participants regarded Indonesian academics / institutions very low in developing the industry.

3.4.4.3 Participant Oriented Analysis

A cross analysis using one-way ANOVA was carried out to ascertain the priorities of the participants in solving the six problems in the Indonesian construction industry. Results of the means and their conversion to ranks for the participants are shown in Table 3.6.

Interpreted horizontally for each type of participant, the owner group for instance, prioritised marketing, financial and legal issues as 1st, 2nd, and 3rd respectively. The designer group prioritised problems as productivity, material shortage and under development of technology, and legal issues and politics as 1st, 2nd ,and 3rd respectively. Contractors placed productivity problems, under development of human resources, and financial problems as needing to be solved in priority order at 1st, 2nd, and 3rd respectively. Similarly, construction specialists prioritised productivity, human resources, and material shortage and its related problem as 1st, 2nd, and 3rd respectively. It is worth noting that designer, contractor, and specialists regarded productivity problems as their first priority. Overall, the priority ranking of the problems were productivity, under-development of human resource, marketing, legal issues and politics, material shortage and technological problems, and financial problems.

Table 3.6 Respondents' Perception of Priority of Problems to Industry Participants.

		CONSTRUCTION INDUSTRY PROBLEMS											
		Material and technological problems		Under development of human resources		Financial problems		Marketing problems		Productivity problems		Legal issues and politics	
PARTICIPANTS	sig.F	mean	rank	mean	rank	mean	rank	mean	rank	mean	rank	mean	rank
OWNERS	.000	4.34	5	3.59	6	7.25	2	7.39	1	5.94	4	6.91	3
DESIGNERS	.000	5.59	2	5.09	4	4.09	6	5.09	4	6.98	1	5.22	3
CONTRACTORS	.000	5.70	6	7.19	2	7.03	3	6.95	4	8.28	1	6.52	5
SPECIALISTS	.004	5.23	3	5.83	2	5.20	4	4.61	5	6.13	1	4.34	6
BANKING	.000	2.88	5	2.36	6	8.02	1	4.28	2	3.13	4	3.72	3
GOVERNMENT	.000	6.81	4	7.33	2	6.14	5	7.56	3	5.63	6	8.31	1
ACADEMIC	.000	4.28	4	6.86	1	2.94	6	3.16	5	4.69	2	4.36	3
MANUFACTURES	.000	7.48	1	4.11	4	4.03	5	4.52	3	5.39	2	3.33	6
Total of ranks			**30**		**27**		**32**		**27**		**21**		**30**
Priority			**4**		**2**		**6**		**2**		**1**		**4**

Overall severity index of industry problems in Indonesia was found 5.9 (1 = low to 10 = high). This value provides a useful trend measure and could also act as benchmark for future comparison. The results of analysis also indicate that Specialists are the group most affected by construction problems with an index of 8.2, followed by Government (6.8), Contractors (5.9), Educational (5.8), Owners (5.6), and Designers (5.5).

3.5 Summary

Results from the Indonesian Construction Industry seem to suggest a divergence of perception of the severity of CI problems by various industry participants. However, there is a convergence of views that under-development of human resources is the most severe problem facing the Indonesian CI today.

The suggested track to solving this problem is through Productivity Improvement Programmes; it's link with under-development of human resources is clearly discernible. Only a well trained and motivated workforce would construct quality buildings at cost effective production rates. To lead the human resource and productivity drive is the Government and Contractors.

CHAPTER 4

CHAPTER 4
A METHODOLOGY FOR EVALUATING CONSTRUCTION PRODUCTIVITY PROBLEMS IN INDONESIA

4.1 Introduction

The previous two chapters have brought about an understanding of Indonesian construction industry problems. Based on the literature and preliminary findings in these chapters, we shall build up a statement of hypothesis on which this dissertation rests. We shall also discuss the experimental procedures and the techniques adopted for testing the hypothesis. Other specific areas of research, reasons and the subsequent data analysis procedure are all discussed in this chapter. We start with the statement of the hypothesis.

4.2 Statement of Hypothesis

In Chapter 2, we examined the nature of the construction industry in Indonesia, its organisation, the contractors and their operating environment, and construction development programmes especially those concerning development of human resources.

In Chapter 3, we investigated the construction industry problems in developing countries with particular emphasis on Indonesia. Six major problems and eight groups of participants were identified. The priority of rankings of different development strategies were also identified.

Based on the literature review and preliminary investigation of the problems of the Indonesian construction industry, three major hypotheses can be drawn as follows:

1. While productivity problems may reflect the evolving nature of the construction industry in developing countries in general, the severity of the problems reflect the uniqueness of each country, in this case Indonesia.

2. To improve productivity on construction sites in Indonesia, there must be agreement by the main on-site participants of the nature, type, and source of problems. A lack of agreement would result only in confusion and lack of a cohesive policy to solving the problems.
3. A productivity audit system capable of tracking the source/type of problems would be beneficial to the industry.

4.3 Data Collection Constructs

Mintzberg (1973) enumerated seven methods for managerial studies: 1). Secondary sources, 2). Questionnaire and interviews, 3). Critical incidents and sequences of episodes, 4). Diaries, 5). Activity sampling; 6). Unstructured observation, and 7). Structured observations. The survey methods employed in this study include secondary sources, questionnaire and interviews, and activity sampling.

The investigation procedure adopted involved questionnaire design and survey / interview of selected craftsmen, foremen, and project managers working on the projects studied. The main tool of data collection were sets of structured questionnaires. The variables identified from literature formed the basis of the questionnaire design. Five questionnaires (craftsmen, foremen, project managers, and comparative productivity questionnaire) and one activity sampling experiment were designed for data collection. A framework developed to achieve the objectives of this study is presented in Figure 4.1.

Validity of data collected is ensured via: (1) Pilot studies were conducted to refine and clarify the questionnaires (including translation to Bahasa Indonesia) and training of interviewers. (2) Systematic care was exercised in selecting craftsmen, and foremen for interview in terms of their willingness to participate and the scope of their supervision. The foremen had to be supervising at least three craftsmen at time of interview.

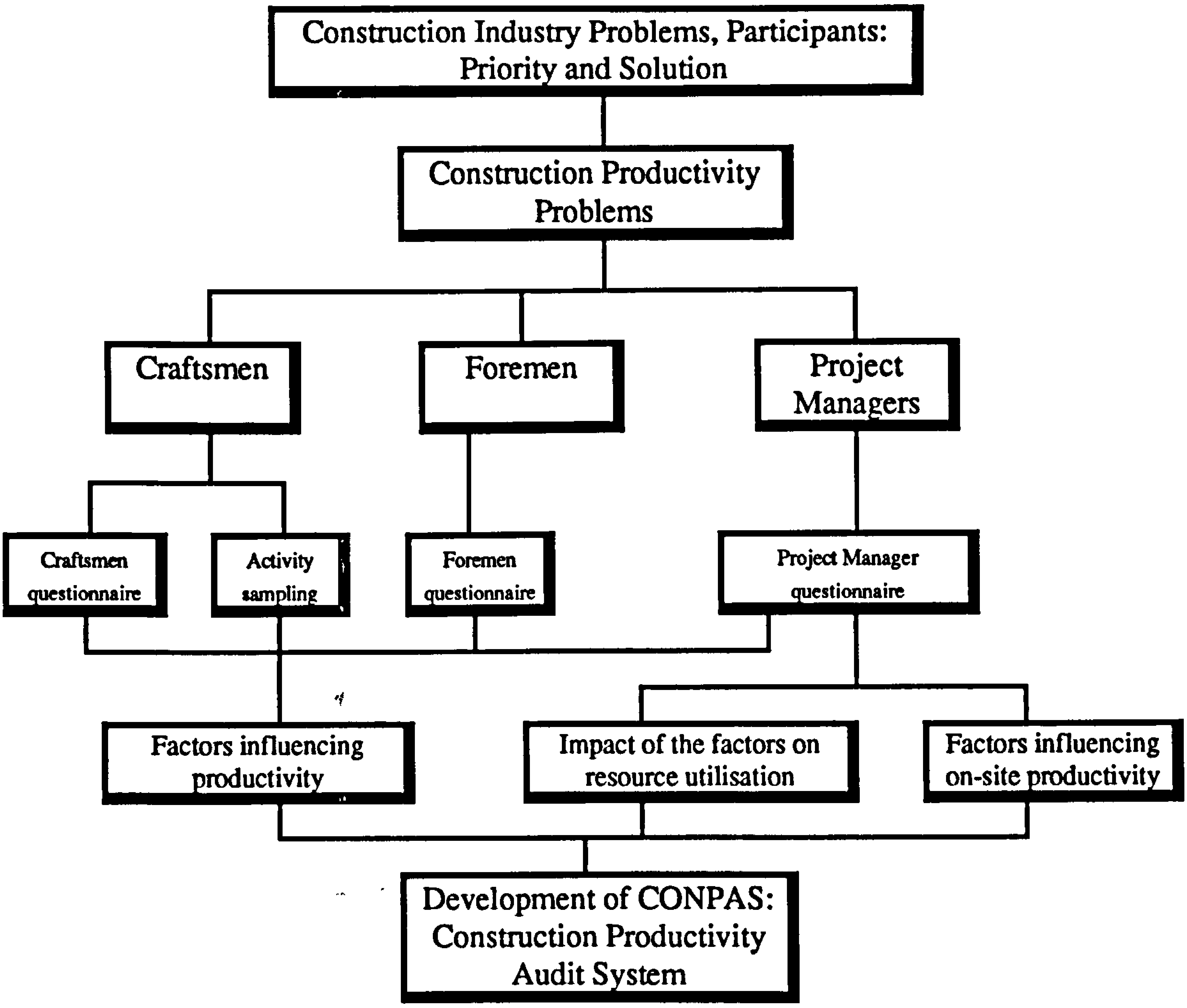

Figure 4.1 A Framework for the Study.

4.3.1 Pilot Survey

This involved structured questionnaire survey and interviews with three construction experts in Indonesia. The purpose was to test the suitability and comprehensibility of the questionnaire. The questionnaire was modified after the pilot survey, factors were added and removed depending on which were deemed appropriate and applicable to the Indonesian construction industry. The pilot questionnaire survey and structured interviews were also applied as a means to test the construct validity of the questionnaire particularly those dealing with the on-site productivity problems by craftsmen, foremen, and project managers.

For comprehensibility, a pilot survey was carried out, and the questionnaire was tested on three project managers, nine foremen, and twenty seven craftsmen currently working on construction sites in Yogyakarta. Three groups of operatives (bricklayers, carpenters, and steelfixers) were selected for the study because they are the main workers on Indonesian construction sites. Before conducting the surveys, permission from the head office was needed to approve visiting and interviewing the personnel on sites. The three construction companies granted their permission and welcomed the investigation because it was considered as the first comprehensive survey carried out on construction productivity in Indonesia. The questionnaires were modified following comments from the respondents. The modified questionnaire formed the basis of the surveys conducted and reported in this dissertation.

4.3.1.1 Measurement / Classification of Variables.

To be classified into one of the four measurement levels (i.e. nominal, ordinal, interval or ratio measurement), a variable must satisfy one of the following criteria (Leedy, 1989):

1) name or designations of discrete units or categories would classify a variable as nominal scale.
2) values such as 'very important' to 'not important', or 'high' to 'low', etc., without the size of intervals belongs to the ordinal scale.
3) equal intervals or degrees of difference with zero point arbitrarily established belongs to the interval scale, e.g. a bricklayer and a carpenter spend time working productively of 6 and 5 hours of working day respectively. We can infer that time spent working productivity by the bricklayer as much as one hour more than that by the carpenter.
4) equal intervals and with an absolute zero point of origin belongs to the ratio scale, e.g., cost per square metre of an office building in the UK and Indonesia is £700 and £350 respectively. The ratio property of the data shows that the cost of office in the UK is twice as much as that in Indonesia.

4.3.1.2 Design of the Craftsman Questionnaire

It is generally acknowledged that craftsmen are more knowledgeable concerning the causes of poor productivity than their supervisor/manager (Chang and Borcherding, 1984). It was for this reason that they were targeted as respondents in this particular research. Part of the questionnaire asked craftsmen to estimate how many hours were lost, for each of a list of productivity problems.

The questionnaire consisted of six sections: personal data, industrial relation, output and methods, productivity, motivation, and foreman leadership (see Appendix B). In section one, foreman personal characteristics were explored in terms of age, training, length of working and type of construction experience. Section two explored employment status, length of working for present site, and present employer; how the foreman rates his present site in terms of construction method, site management, working environment, and craftsmen remuneration; and characteristics of the foremen's direct superior.

Section three explored gang ratio through investigating craftsmen - helper ratio; and time spent unproductively by craftsmen in a typical working week. Section four investigated time lost due to productivity problems such as lack of resource, rework, workers interference, absenteeism, and so on. The first question applied an interval scale, whilst the remaining questions regarding investigation of the probable causes of the problems employed ordinal scales. Section five investigated worker turnover, and its probable causes using a ratio scale.

Section six investigated craftsman motivation through two sets of motivation factors: the motivating and demotivating factors. The questionnaire in this section was patterned after the Michigan Organisational Assessment Package (1975). The craftsmen were asked to rate the importance level (I) of each factor based on their past experience (without relating to their present sites) ranging from 4 (very important) to 1 (not important) and zero for not applicable. They were also asked to indicate the frequency of occurrence (F) of each motivating and demotivating factor on their present sites from 3 (high) to 1 (low).

4.3.1.3 Design of the Foreman Questionnaire

The foreman questionnaire design employed a similar pattern and scales to the craftsman questionnaire consisting of six sections: personal data, industrial relation, span of control and methods, productivity, motivation, and project manager leadership (see Appendix C). In section one, foreman personal characteristics were explored in terms of age, training, length of working and type of construction experience. Section two explores employment status, length of working for present site, and present employer; how the foreman rated his present site in terms of construction method, site management, working environment, and remuneration; and characteristics of the foremen's direct superior.

Section three explored span of control through investigation of foreman and craftsmen ratio; and how the foreman spends time in a typical working week. Section four investigates productivity problems such as lack of resource, rework, workers interference, absenteeism, and so on. These were subsequently followed by investigating their probable causes.

Section five investigated foreman motivation through two sets of motivation factors: the motivating and demotivating variables. They were asked to rate the importance level (I) of each factor based on their past experience (without relating to their present sites) ranging from 4 (very important) to 1 (not important) and zero for not applicable. They were also asked to indicate the frequency of occurrence (F) of each motivating and demotivating factor on their present sites from 3 (high) to 1 (low). Section six investigated project manager leadership factors through a list of 14 questions that can be classified into five categories: problem solving, administration, supervision team management, interpersonal relation, and personal quality.

4.3.1.4 Design of Project Managers Questionnaire

The PM questionnaire consists of six sections: general information on the project, subcontractor employment, productivity problem, contract manager leadership, on-site productivity improvement and resource utilisation (see Appendix D). In section one, length of working and type of construction experience of project managers were assessed, followed by information of the current project in terms of time and cost, percentage completed; and percentage of expenditure on materials, labour, equipment, and over-heads. A nominal scale was applied to question 1 to 4 as general information on contractors and experience of project managers in construction business, followed by question 5 about information on their current project using an interval scale, and question 6 concerning a ratio of project expenditure in terms of site overheads, labour, equipment, and material, using a ratio scale measurement.

Section two explored delays and cost overruns experienced by project managers on past and present projects. These questions were patterned after the Michigan Organisational Assessment Package using an interval scale. Section three explored subcontractor employment and reasons for employing sub-contractors using an interval scale measurement. Section four investigated productivity problems such as lack of resource, rework, workers interference, absenteeism, and so on using the same measurement as in section two. These were subsequently followed by investigation of their probable causes using a ratio scale. Section five investigated leadership factors through a list of 14 questions that can be classified into six categories and scales of measurement similar to the foreman questionnaire. Section seven investigated 1) factors with respect to opportunity for improving on-site productivity in construction, and 2) indication of degree of effectiveness of the factors regarding resource utilisation (time, material, labour, and plant). Question 1 in this section adopted an ordinal scale for importance rating of the factors using a scale ranging from 'very important' (4) to 'not important' (1). Similarly, question 2 applied an ordinal scale to measure the degree of influence of the factors on effective resource utilisation ranging from high (3) to low (1).

4.3.2 Activity Sampling

4.3.2.1 Definition and Classification of Working Time

A typical construction working time may be classified into two broad categories: productive and unproductive (Broomfield, et.al. 1984; Olomolaiye, et.al., 1987; BSI, 1985). The productive portion of working time is hours spent on construction activities, for example laying bricks, fixing formwork, and fixing steel rods. Unproductive time is associated with time lost in one or all of the following six categories:

(1) Internal delays - including times when materials are unavailable and/or crew and machine interference.

(2) Lack of skill - including operational mismanagement.

(3) Waiting and relaxation - including waiting for instructions, supervision and chatting amongst workmates.

(4) Supervision - including time spent understanding the construction specification, and drawings etc.

(4) Extra breaks - including late starts and early quits.

(6) Official breaks - including afternoon breaks at 12.00 to 13.00 PM. and Fridays 11.00 to 12.00 (prayer time for Moslem workers).

4.3.2.2 Number of Observations

For this survey, productive and unproductive times were surveyed on twenty seven sites using activity sampling as defined by NEDO (1989). In addition to activity sampling, craftsmen in the surveys were approached via a structured questionnaire survey to collect information on their views of construction processes and to examine any relationships between 'hard' data collection via activity sampling and the relatively 'soft' data from the questionnaire surveys. Thomas (1991) has roundly condemned activity sampling as being unsuitable for productivity measurement on construction activities. Instead he recommended the factor model technique which is yet to be accepted internationally. Because of the international acceptance of work study in general, it has been chosen as the appropriate tool for this research. A careful observation and utilisation of data collected by activity sampling would avoid unnecessary bias. After identifying their age groups, length of service in the construction industry and variability of experience, the craftsmen were asked to identify, and rank in order of importance, the frequency of problems that lead to unproductive time.

Each craftsman was observed using the NEDO activity sampling technique on five work items: working, walking, talking with supervisor, talking with mate and in-active (see Appendix A). The first item is defined as productive work whilst the others are unproductive. Two assumptions were made before carrying out the activity sampling. First, that the craftsmen would not be interrupted or given any instruction during observation. Therefore any observation showing discussion between craftsmen and supervisor has to be remarked as an ordinary chat. 'Walking', even to fetch tools is considered as unproductive work. The following formula is applied as the basis for determining the number of observations:

$$N = \frac{Z^2 * P * (1-P)}{L^2}$$

where N = number of observation required, P = percentage of activity observed (from pilot study), L = limit (%) of accuracy required, and Z = value obtained from statistical tables depending upon the level of confidence required for estimate (normally taken as 2, which corresponds to 95% confidence).

A 95% confidence level is considered to be adequate for this study. The main problem with using this technique is that watching a craftsman working in a defined pattern on a particular day does not mean that he will repeat that pattern every day. To safe guard against this, observation were taken over three days, on three hundred and sixty separate occasions randomly chosen within the period the author and four assistants were on sites, for every craftsman taking part in this study. The determination of number of observation is based of assumption that unproductive time occupies 30% of the total working time. The number of observation is:

$$N = \frac{4 * 30 * 70}{5^2} = 336$$

approximated to 360

Although this does not totally remove the doubt due to the craftsman varying his working pattern daily, it boosts confidence in the data. The assumption of the 30% unproductive time would be tested later when all data are analysed.

4.3.3 Comparative Survey Questionnaire

Koehn and Brown (1986) conducted a comparative study of International labour productivity. Using construction labour output (unit labour time / unit area) of Washington D.C. as a benchmark, they produced a comparable labour adjustment factor for 47 nations. Employing the same technique, a structured questionnaire was developed and used to interview site personnel on the 27 projects studied.

Indonesia officially consists of 27 provinces which are spread over 14 thousand islands. The main islands are Sumatera, Java, part of Kalimantan, Sulawesi, and Irian Jaya (part of Irian island). Since Java is the most developed island, with 6% of the total area of Indonesia occupied by almost 60% of the overall population, it is fair to say that the majority of construction workers are from Java.

For the purpose of this study, the 27 provinces were divided into seven regions: Yogyakarta, Jakarta, West of Java, Centre of Java, East of Java, Western region of Indonesia, and Eastern region of Indonesia. Western region of Indonesia included Sumatera (including Batam island) and Kalimantan. The Eastern region included Sulawesi, Nusa Tenggara (excluding Bali, Maluku islands, and Irian Jaya. In this survey, Yogyakarta was set as a benchmark simply because of its centrality and also, the region is a major centre of education in Indonesia.

In this survey, Yogyakarta (benchmark) has its 12 comparable items assigned standard value of 1.00. The participating site agents then assigned comparative values (which could be classified as a ratio scale) for the variables considered with respect to the regions where they had worked in the past. For instance, if a bricklayer from Yogyakarta, working on construction site in Yogyakarta could lay 100 bricks in a given period of time, how many could a bricklayer from another region lay ? Table 4.1 shows that Jakarta, Centre of Java, and Eastern region of Indonesian craftsmen can lay an average 130, 105, and 80 bricks respectively over the same period of time, and provide three sets of data that can be compared to the benchmark (i.e. Yogyakarta 1.00; Jakarta 1.30; Centre of Java 1.05; Eastern Region of Indonesia 0.80). The survey instrument is supplied in Appendix E.

Table 4.1 A Sample Answer Sheet of Productivity Related Variables in Seven Regions of Indonesia.

Construction Operatives' Productivity Related Variables	**Regional Deviation**							**Remark**
	1	**2**	**3**	**4**	**5**	**6**	**7**	
Bricklayer production output	1.00	1.30	-	1.05	-	-	0.80	-
Carpenter production output	1.00	1.30	-	1.05	-	-	0.80	-
Steelfixer production output	1.00	1.30	-	1.05	-	-	0.80	-
Craftsmen production output	1.00	1.30	-	1.05	-	-	0.80	-
Time spent working	1.00	1.30	-	1.05	-	-	0.80	-
Craftsmen motivation	1.00	1.20	-	1.10	-	-	0.80	-
Craftsmen skill level	1.00	1.40	-	1.20	-	-	0.70	-
Craftsmen remuneration	1.00	1.70	-	1.10	-	-	1.30	-
Level of supervision	1.00	1.20	-	1.00	-	-	0.90	-
Foremen motivation	1.00	1.30	-	1.00	-	-	0.90	-
Foremen remuneration	1.00	2.00	-	1.10	-	-	1.50	-
Severity productivity problems	1.00	0.70	-	1.00	-	-	1.30	-

Note: 1, 2, 3, 4, 5, 6, and 7 represents Yogyakarta (as a benchmark), Jakarta, West of Java, Centre of Java, East of Java, Western region of Indonesia, and Eastern region of Indonesia respectively. The respondent has experience with operatives in four of these seven regions.

4.4 The Surveys

4.4.1 Projects and Contractors

Contractors working on high-rise construction in Yogyakarta and Jakarta were invited to participate in the main study. The selection of these two cities is based on the premise that Yogyakarta represents non-centre region, whilst Jakarta represents centre region; with more economic activities and infrastructural development. Twenty seven medium to high-rise construction sites in Indonesia participated in the investigation.

The projects consisted: 8 schools, 9 commercial offices, 4 shopping centres, 6 apartments, 1 hotel building, and 2 others (hospital and auditorium). A total of fourteen small to large size contractors were responsible for the projects. Table 4.2 offers a tabulated description of each project. For example, Project 1 is a school building, with contract sum of about 1.5 billion rupiah, contract duration of 12 months, stage of actual completion 45% and has 15% of delay. (Percentage delay is calculated based on the difference between programmed completion and actual completion). The mean contract sum of the 27 projects was 12.40 billion rupiah, contract duration was 12.7 months, stage of actual completion was 38.70%, and average of delay 5.50%.

4.4.2 Craftsmen Survey

It is not possible to cover every construction operative in such a research as this due to finance and other practical purposes. The investigation was limited to three main trades: bricklaying, carpentry, and steel fixing (because most operatives work in these trades on high-rise construction). Brick laying, block laying, concreting, plastering and tile fixing are categorised into the 'bricklaying' group. Roofing, ceiling fixing work, formwork, window and door fixing are included in the 'carpentry' group. Fixing steel bar reinforcement for concrete structures was the main activity for steel fixers. Also, as the majority of steel reinforcement is cut and bent on site, this activity was incorporated within the 'steel fixing' group.

Table 4.2 Characteristics of Projects Surveyed.

Proj. Id.	Co. Id	Type of Building	Procurement methods	Area (m^2)	Duration (months)	Cost (100000 Rupiah)	Stage of Completion (%)	Delay (%)
1	1	School	DB	3650.00	12.00	1500	45.00	15.00
2	2	Office	EPC	2000.00	10.00	1500	50.00	10.00
3	2	Office	EPC	2400.00	7.00	1200	52.00	3.00
4	3	Office	EPC	2400.00	7.00	2100	60.00	0.00
5	3	Office	EPC	1350.00	8.00	1000	12.00	0.00
6	3	Hospital	DB	6519.00	10.00	1730	70.00	0.00
7	4	Apartment	CM	10200.00	8.00	1600	25.00	5.00
8	4	Hotel	CM	*	24.00	27500	60.00	14.00
9	4	Office	CM	1225.00	12.00	1030	15.00	0.00
10	4	School	EPC	3160.00	7.00	1850	11.00	0.00
11	5	Shopping	EPC	15000.00	14.00	5165	40.00	0.00
12	6	School	DB	5000.00	12.00	2000	40.00	0.00
13	7	Shopping	CM	*	15.00	23000	42.00	27.00
14	7	Apartment	EPC	33060.00	18.00	24000	31.00	15.00
15	7	Office	CM	6006.00	12.00	9400	70.00	14.00
16	8	Office	CM	4089.00	10.00	2100	40.00	0.00
17	9	School	CM	7000.00	10.00	3100	8.00	5.00
18	10	School	CM	4000.00	10.00	2200	30.00	0.00
19	11	School	EPC	4962.00	8.00	2390	70.00	14.00
20	11	School	EPC	1500.00	5.00	825	12.00	8.00
21	12	Auditorium	EPC	5400.00	15.00	2250	51.00	0.00
22	13	Apartment	EPC	27400.00	18.00	32300	80.00	0.00
23	13	Office	CM	*	15.00	31000	40.00	0.00
24	13	Apartment	EPC	55000.00	27.00	27000	42.00	7.00
25	14	Shopping	EPC	56287.00	19.00	63000	8.00	6.00
26	14	School	DB	8000.00	10.00	6700	22.00	4.00
27	14	Apartment	EPC	68798.00	20.00	60000	20.00	2.00
		AVERAGE		20737.71	12.70	12500	38.70	5.50

Note : * missing value; £ 1 = Rp 3500 in 1995; DB = Design and Build, EPC = Traditional Engineering Procurement and Construction, and CM = Construction Management.

Overall, 243 craftsmen: (93 bricklayers, 81 carpenters, and 69 steel fixers on 27 sites) were observed for activity sampling and interviewed using the questionnaire (see Table 4.3). The project leader ensured consistency of observation and interviewing throughout the data collection period. Only craftsmen selected as respondents to the questionnaires were observed in the activity sampling. For the first day on each site craftsmen were not informed of the activity sampling. This was in order to provide data comparison for situations where the craftsmen were studied unknowingly and after they had been informed. Finally, discussions of the results of interviews and activity sampling on each site were carried out on a daily basis. Because of the careful approach to this survey, the author is confident of the quality of data collected.

4.4.3 Foremen Survey

Following the craftsmen, their direct foremen were selected to be representative of middle management. They were also from the three main groups of bricklaying, carpentry, and steelfixing. The foremen were employed either by main contractors, subcontractor, or labour-only subcontractor. Three foremen from each site were selected for the survey, ideally from the three different trades. In all, 81 foremen (32 bricklaying, 26 carpentry, and 23 steelfixing foremen on 27 sites) were successfully questioned and interviewed. The author ensured consistency of observation and interviewing throughout the data collection period. Only foremen whose craftsmen were observed in the activity sampling and who also responded to the questionnaire survey were selected as respondents (see Table 4.3).

Table 4.3 Type and Number of Craftsmen and Foremen who Participated in this Study.

	Bricklaying	Carpentry	Steelfixing	Overall
Craftsmen	93	81	69	243
Foremen	31	27	23	81

4.4.4 Comparative Survey of Seven Regions

Twenty site personnel consisting of 2 general superintendents (GS), 10 site managers (MS), and 8 project managers (PM) provided the data for the comparative survey between regions. Those surveyed were required to have had experience of workers from Yogyakarta, and at least one other region. A sample of the structured questionnaire sheet is shown in Table 4.4 as answered by one participant who had experience of workers from Yogyakarta, Jakarta, Centre of Java and Eastern Regions of Indonesia thereby accounting for 4 sets of data.

Respondents provided 78 separate sets of comparable data which form the basis of the analysis reported in Chapter 8. Twenty data sets were from Yogyakarta, 13 from Jakarta, 8 from West of Java, 16 from Centre of Java, 12 from East of Java, 2 from Western Region of Indonesia, and 7 from Eastern Region of Indonesia.

4.5.5 Survey of Project Managers

The project manager on each site was targeted not only for the identification of the productivity problems, but also for contribution of knowledge to improving construction productivity. Majority of the PMs graduated as Civil Engineers from University. Seven PMs have had experience of more than 20 years in construction business, eight PMs between 10 to 20 years; and 11 PMs up to 10 years experience in construction.

The questionnaire gave each respondent an opportunity to identify factors that were likely to be contributing to productivity problems on their sites on a scale from 4 (very important) to 1 (not important), and zero for a variable that they considered not applicable. They were then asked to rate the frequency of occurrence of each variable on their present construction site on an ordinal scale from high (3), medium (2), and low (1). For each variable, the mean value of the respondents importance response was labelled "the importance index". Secondly the mean value from the respondents frequency responses was labelled the "frequency index". These indices were used to rank the frequency of occurrence of the variables on their sites. Finally the mean value from multiplying the respective importance and frequency responses was labelled "the severity index" which was used to rank the severity of the variables on the construction sites.

Table 4.4 Some Characteristics of the Project Personnel Surveyed.

Resp. ID	Current Position	Years in Constr. Industry	Work Experience of Project Managers within the Regions						
			1	2	3	4	5	6	7
1	PM	20	*	*	*	*			
2	PM	15	*	*		*			*
3	PM	12	*	*		*			
4	SM	15	*	*	*	*	*		*
5	SM	30	*	*		*	*	*	*
6	SM	11	*	*				*	
7	GS	22	*	*	*	*	*		*
8	PM	12	*	*	*	*	*		*
9	PM	20	*		*	*	*		
10	GS	20	*				*		
11	SM	20	*	*			*		
12	SM	8	*		*	*			
13	PM	15	*			*	*		*
14	SM	7	*	*		*			
15	PM	20	*	*	*	*	*		
16	SM	10	*			*	*		*
17	PM	20	*	*	*	*	*		
18	SM	8	*	*		*			
19	SM	12	*			*			
20	SM	8	*				*		
		Sum	20	13	8	16	12	2	7

Note: 1, 2, 3, 4, 5, 6, and 7 represents Yogyakarta (as a benchmark), Jakarta, West of Java, Centre of Java, East of Java, Western region of Indonesia, and Eastern region of Indonesia respectively. * indicates regions in which respondents have experience with operatives.

4.4.6 Survey of Construction Experts

Seven experienced senior project managers who are the 'productivity champions' in their respective companies were asked questions relating to productivity improvement strategies to form the qualitative knowledge base for the development of the productivity audit system.

Some characteristics of the experts are listed in Table 4.5. All the experts graduated as Civil Engineers and on the average have experience of construction productivity issues of at least 15 years each.

Table 4.5 Profile of the Seven Experts.

Id.	Educational / Professional Background	Years in Construction Business	Current Position in Company
1	Civil Engineer	> 20	Project Co-ordinator
2	Civil Engineer	> 20	Project Co-ordinator
3	Civil Engineer	> 20	Project Co-ordinator
4	Civil Engineer + MBA	15 - 20	Senior Project Manager
5	Civil Engineer + M.Eng	15 -20	Senior Project Manager
6	Civil Engineer + M.Sc	15 - 20	Senior Project Manager
7	Civil Engineer	> 20	Contract Manager

4.5 Data Analysis Techniques

Data from both pilot and main surveys were analysed using the Statistical Package for the Social Sciences (SPSS). Unless otherwise stated, all levels of analysis was set at 95% significance level. The statistical technique employed in this study included: 1. Correlation Analysis, 2. Analysis of Variance, 3. One sample t-test. 4. Friedman One-way Analysis of

Variance, 5. Kendall Concordance Analysis, 6. Multiple Regression Analysis. For the basic descriptions of these analysis methods, please see Appendix F.

Beside the statistical analysis techniques, multiple criteria decision making technique such as Relative Weighting Technique is employed, especially with respect to developing weighting of the factors into an audit system for improving on-site productivity.

4.6 Summary

This chapter has explained the hypotheses for this research together with the data collection and analysis approaches taken. It explains how the experiments have been carried out in order to understand the analysis, discussion and findings in the next six chapters.

CHAPTER 5

CHAPTER 5

CONSTRUCTION PRODUCTIVITY PROBLEMS IN INDONESIA - A SURVEY OF CRAFTSMEN

5.1 Introduction

Poor productivity of construction craftsmen is one of the most daunting human resource problems in developing countries. This chapter reports an investigation of the problems influencing craftsmen's productivity on twenty seven medium and high-rise building sites surveyed in Indonesia. Three main groups of craftsmen (93 bricklayers, 81 carpenters and 69 steel fixers) some two hundred and forty three operatives in total, participated in a comprehensive structured survey of production problems conducted over a 4-month period. The study instruments included craftsmen questionnaires and an activity sampling survey (see Chapter 4).

The construction industry is characterised by repeated delays and cost overruns, even more so in developing countries (Okpala and Aniekwu, 1988; Werna, 1993; Mansfield, et.al., 1994). In many instances, these time and cost overruns have been so severe, that serious questions on the efficiency of human factors in the construction process have started to emerge (see Imbert, 1990).

Factors influencing the productivity of construction operatives' in developed countries have been explored extensively over the last two decades. For instance, Borcherding (1975) investigated effective utilisation of manpower in construction; Borcherding (1978) identified potential factors influencing productivity on large projects; Whilst Sebastian and Borcherding (1979) explored major factors influencing craftsman productivity on nuclear power plant construction in the USA. Furthermore, Borcherding and Garner (1981) and Maloney and McFillen (1986; 1987a) examined workforce motivation and productivity.

Thomas (1981) employed activity sampling to investigate labour productivity, whilst Horner, et.al (1987) elaborated on the relationship between management control and labour productivity.

Until Thomas et.al (1990) introduced the factor model technique to investigate labour productivity, construction labour productivity research projects primarily employed task (activities) models. Adopting the pre 1990s technique of investigation, Olomolaiye, et.al, (1987) investigated factors influencing craftsmen's productivity in Nigeria; Parker, et.al (1987) analysed labour productivity in Tanzania, and Rahman, et.al (1990) surveyed labour management problems in Malaysia. Overall, construction craftsman productivity research is typically in its infancy with regard to *developing* countries.

Indonesia, is the fourth most densely populated country in the world, with almost one hundred and ninety million inhabitants. The country has therefore adopted a labour intensive strategy to support its economic development. Although the construction sector contributes 5.5% of the gross domestic product (GDP), there has not been any significant research into construction productivity since the country achieved independence in 1945. The lack of any research effort into the performance of the Indonesian construction industry, is compounded by the poor level of formal education amongst construction operatives (see Chapter 2).

With increasing demand for a more efficient construction industry to underpin infrastructural development in the growing economy, there is now an urgent need to identify the main problems confronting Indonesian craftsmen. Subsequently, appropriate solutions aimed at improving this poor construction productivity may then be advanced. Therefore, the research on which this chapter is based focused on identifying factors influencing craftsmen's productivity in Indonesia and further compares these factors, with those identified in earlier studies pertaining to Nigeria, the UK and the USA. The ultimate aim being to devise an appropriate strategy, generally for improving craftsmen's productivity in developing countries and particularly in Indonesia.

5.2 Characteristics of Indonesian Craftsmen

5.2.1 Characteristics of Operatives Surveyed

Ninety percent of the craftsmen were employed by 'Labour-only' sub-contractors, 7% by main contractors, and only 3% by main sub-contractors. These proportions are similar amongst the three groups of craftsmen with 'Labour-only' sub-contractors dominating the employment of craftsmen in Indonesia (see Table 5.1).

Table 5.1 Type of Employer

	Number and Percentage of Craftsmen			
Worked under	**Bricklayers**	**Carpenters**	**Steelfixers**	**Total**
Sub-contractor Labour	85	75	59	219
Only	91.4%	92.6%	85.5%	90.1%
Sub-contractor	5	0	1	6
	5.4%	0%	1.4%	2.5%
Main contractor	3	6	9	18
	3.2%	3.7%	13.0%	7.4%

On average, most of the craftsmen (64%) had been employed for less than two years. This exemplifies the unstable pattern of employment throughout the Indonesian construction industry. The most unfavourable pattern being amongst steel fixers with 72% employed for less than two years which may be linked to the high proportion employed as 'labour only' sub-contractors (see Table 5.2).

Table 5.2 Length of Stay with Employer.

Worked under present boss/employer (years)	Number and Percentage of Craftsmen			
	Bricklayers	Carpenters	Steelfixers	Total
0 - 2	58	47	49	154
	62.4%	58.0%	72.1%	63.6%
2 - 5	20	24	14	58
	21.5%	29.6%	20.6%	24.0%
5 - 10	13	8	4	25
	14.0%	9.9%	5.9%	10.3%
10 - 20	1	1	1	3
	1.1%	1.2%	1.5%	1.2%
> 20	1	1	0	2
	1.1%	1.2%	0%	0.8%

Table 5.3 presents the length of stay of craftsmen on their present sites. The majority of craftsmen (70%) had worked on their present sites for up to 3 months. The 27 projects studied had been running for an average of 5 months (see Chapter 4, Table 4.1) at the time the surveys were carried out. It would be reasonable to assume that most of the craftsmen had been on site since (or shortly after) project inception and would therefore be conversant with production problems.

Table 5.3 Length of Stay on Current Project.

Worked for present project (months)	Number and Percentage of Craftsmen			
	Bricklayers	Carpenters	Steelfixers	Total
0 - 3	71	49	49	169
	76.3%	60.5%	72.1%	69.8%
3 - 6	14	23	13	50
	15.1%	28.4%	19.1%	20.7%
6 - 12	6	9	5	20
	6.5%	11.1%	7.4%	8.3%
> 12	2	0	1	3
	2.2%	0%	1.5%	1.2%

Table 5.4 Age of Craftsmen.

	Number and Percentage of Craftsmen			
Age Groups (years)	Bricklayers	Carpenters	Steelfixers	Total
15 - 20	9	3	9	21
	9.7%	3.7%	13.0%	8.6%
20 - 30	34	40	36	110
	36.6%	49.4%	52.2%	45.3%
30 - 40	33	21	19	73
	35.5%	25.9%	27.5%	30.0%
40 - 50	11	10	4	25
	11.8%	12.3%	5.8%	10.3%
> 50	6	7	1	14
	6.5%	8.6%	1.4%	5.8%

Fifty four percent of the craftsmen were aged below 30 years indicating that construction craftsmanship is a young man's trade in Indonesia. The age distribution for each of the trades is different. Forty six percent of bricklayers, 53% of carpenters, and 65% of steel fixers are below 30 years of age respectively. Since reinforced concreting work in high rise construction is physically demanding it is not surprising that a significant proportion of steel fixers are young. Note that the age distribution is significantly different from those of the more traditional trades. The concentration of workers in the younger age group is reflected in their experiences which in terms of number of years is limited. Only 52.3% of the craftsmen surveyed had been in the construction industry for up to 5 years.

When craftsmen's experience was analysed by type of building (see Table 5.5) it was discovered that the majority of construction workers started their career on relatively simple housing projects but rapidly progressed onto more complex industrial and commercial projects. The desire to work on an industrial project (particularly by the young craftsmen), complements the view that since the country is becoming industrialised, specialising in these projects can only lead to better employment prospects.

Table 5.6 presents the craftsmen's training and educational backgrounds. Eighty six percent were trained on-site, learning from their seniors. From interviews, it was discovered that working gangs consisted of relatives or neighbours from the same village. The fact that only 9% of craftsmen have been formally trained in trade schools and Government workshops, confirms the limited attention being paid by the Government to proper skill based education and training. It would also seem that main contractors are not interested in any formal skill acquisition programme for craftsmen working on their sites. Neither have the professional institutions and trades associations e.g. Construction Association of Indonesia GAPENSI and AKI initiated any training programmes.

Table 5.7 exhibits experience of craftsmen by types of building. It shows that the majority of craftsmen has experience less than 5 years. In housing, 42% of craftsmen under this survey have less than to 2 years experience, 37% has 2 to 5 years, and only 22% has more than 5 years. Thirty two percent of craftsmen working on commercial building sites have 5 years experience, considerably higher than in other types of building. Only 9% of craftsmen working on industrial building sites have 5 years experience.

Table 5.5 Experience of Craftsmen.

	Number and Percentage of Craftsmen			
Experience in years	**Bricklayers**	**Carpenters**	**Steelfixers**	**Total**
0 - 2	19	10	15	44
	20.4%	12.3%	21.7%	18.1%
2 - 5	30	31	22	84
	32.3%	38.3%	31.9%	34.2%
5 - 10	22	20	20	62
	23.7%	24.7%	29.0%	25.5%
10 - 20	16	9	8	33
	17.2%	11.1%	11.6%	13.6%
> 20	6	11	4	21
	6.5%	13.6%	5.8%	8.6%

Table 5.6 Types of Training / Education Background.

	Number and Percentage of Craftsmen			
Type of training	**Bricklayers**	**Carpenters**	**Steelfixers**	**Total**
Apprenticeship	1	4	6	11
	1.0%	4.8%	8.0%	4.0%
Formal Trades School	8	8	3	19
	8.1%	9.6%	4.0%	7.0%
On-site Trained	88	71	63	222
	80.8%	85.6%	84.0%	86.0%
Government Workshop	2	0	3	5
	2.0%	0%	4.0%	2.0%

Table 5.7 Experience by Types of Building.

Type of Building	Number and percentage of Craftsmen			
Housing	**Bricklayers**	**Carpenters**	**Steelfixers**	**Total**
< 2 years	25	24	24	73
	33.3%	40.0%	58.8%	41.5%
2 - 5 years	32	22	11	65
	42.7%	36.7%	26.8%	36.9%
≥ 5 years	18	14	6	38
	24.0%	23.3%	14.6%	21.6%
Public Utility				
< 2 years	15	15	9	39
	41.7%	51.7%	52.9%	47.6%
2 - 5 years	15	9	5	29
	41.7%	31.0%	29.4%	35.4%
≥ 5 years	6	5	3	14
	16.7%	17.2%	17.6%	17.1%
Industrial				
< 2 years	21	8	13	42
	67.7%	50.0%	72.2%	64.6%
2 - 5 years	6	7	4	17
	19.4%	43.8%	22.2%	26.2%
≥ 5 years	4	1	1	6
	12.9%	6.3%	5.6%	9.2%
Commercial				
< 2 years	23	18	17	58
	27.1%	24.0%	27.4%	26.1%
2 - 5 years	32	34	26	92
	37.6%	45.3%	41.9%	41.4%
≥ 5 years	30	23	19	72
	35.3%	30.7%	30.6%	32.4%

5.2.2 Craftsmen's Perception of On-site Practices and Management

An assessment was made of the craftsmen' perception of construction methods, site management, working environment, and remuneration on their respective sites. Respondents were asked to rank these aspects of their on-site practices and management on a 5 point likert scale with 5 (very good) to 1 (very poor). Table 5.8 presents the results of their assessments. On average, 59% of the craftsmen rated construction methods employed on their sites as 'good' and about 9% rated them 'very good'. Complementing this rating of construction methods is the craftsmen's rating of on-site management. Sixty eight percent of craftsmen rated their 'on-site management as 'good' to 'very good' (see Table 5.9). On examining the relationship between the rankings for 'construction method' and 'on-site management' a Spearman correlation coefficient (Rs) of 0.84 was established suggesting good construction methods are significantly related to good on-site management being employed.

Table 5.8 An Evaluation of Method of Construction.

Evaluation of Method of Construction	**Number and Percentage of Craftsmen**			
	Bricklayers	**Carpenters**	**Steelfixers**	**Total**
Poor	5	3	0	8
	5.4%	3.8%	0%	3.3%
Fair	30	28	11	69
	32.3%	35.0%	16.7%	28.9%
Good	57	45	39	141
	61.3%	56.3%	59.1%	59.0%
Very good	1	4	16	21
	1.1%	5.0%	24.2%	8.8%

Table 5.9 An Evaluation of Site Management.

Site Management	Number and Percentage of Craftsmen			
	Bricklayers	**Carpenters**	**Steelfixers**	**Total**
Poor	9	0	0	9
	9.7%	0%	0%	3.8%
Fair	25	33	10	68
	26.9%	41.3%	15.2%	28.5%
Good	59	42	44	145
	63.4%	52.5%	66.7%	60.7%
Very good	0	5	12	17
	0%	6.3%	18.2%	7.1%

The working environment reflects safety, supervision quality, physical and physiological variables at the place of work. Sixty percent of craftsmen rated working environment as 'good' (see Table 5.10). Working environment was also found to be significantly correlated to construction methods (R_s = 0.48) and site management (R_s = 0.49); although the strength of the relationships are not as strong as that between construction methods and on-site management.

Table 5.10 An Evaluation of Working Environment.

	Number of Craftsmen			
Working Environment	**Bricklayers**	**Carpenters**	**Steelfixers**	**Total**
Poor	3	3	1	7
	3.2%	3.7%	1.5%	2.9%
Fair	39	22	15	76
	41.9%	27.2%	22.7%	31.7%
Good	50	51	45	146
	53.8%	63.0%	68.2%	60.8%
Very good	1	5	5	11
	1.1%	6.2%	7.6%	4.6%

Table 5.11 presents the aggregation of craftsmen's response to a question evaluating their remuneration. Craftsmen generally rated their remuneration as being 'poor' to 'fair'. In fact 72% of them rated it as poor. Considering the fact that most of these workers were 'labour only' sub-contractors being paid negotiated prices on a daily basis, one may wonder why so many consented to the price when they knew it was poor. In a market where prices are fixed by the force of supply and demand, the workers are partly responsible for their poor reward situation. However, how would a worker survive if he did not agree to work for the little being offered? Indonesia is known as a low wage economy and currently suffering from unemployment and industrial disputes across all of its industrial sectors. Presently, construction workers who refuse to accept low remuneration can easily be replaced.

Table 5.11 An Evaluation of Level of Payment.

Payment	Number and Percentage of Craftsmen			
	Bricklayers	Carpenters	Steelfixers	Total
Poor	13	4	3	20
	14.0%	4.9%	4.5%	8.3%
Fair	54	56	42	152
	58.1%	69.1%	63.6%	63.3%
Good	19%	20%	19%	58%
	20.4	24.7	28.8	24.2
Very good	7	1	2	10
	7.5%	1.2%	3.0%	4.2%

5.2.3 Unproductive Time

First, craftsmen were asked to estimate unproductive hours lost in a typical week. Table 5.12 presents the results with the unproductive time classified as previously described. The results provide the hours lost and the ranking of causes of unproductive time in a typical week. Official breaks were not included in the analysis.

On average, craftsmen lose time in Indonesia because of: internal delays (39%), extra breaks (23%), waiting and relaxation (17%), lack of skill (16%), and supervision delay (5%). Overall, craftsmen claimed they lose a total of 18% of working time per week due to one production problem or another. Notably, bricklayers lose more time than the others mainly due to extra breaks. There was no significant difference in the overall time lost by both carpenters (15%) and steel fixers (15%).

The proportion of unproductive time discovered in this study is comparatively lower than that associated with Nigeria and the UK where unproductive time is about 50% (see Olomolaiye, 1988). However, the output of craftsmen (especially) in the UK is much higher although they work for fewer hours. This suggests that craftsmen in Indonesia, although working longer hours, and spending more time working, achieve lower production output possibly due to lack of skill. As indicated in the survey, low levels of training and education of craftsmen is affecting their performance.

Table 5.12 Unproductive Time in a Typical Working Week.

	Time Lost in Hours			
Classification	**Bricklayers**	**Carpenters**	**Steelfixers**	**Average**
Internal delay	2.28 26.4%	2.89 46.9%	3.21 53.4%	2.75 38.9%
Lack of skill	1.92 22.2%	0.96 15.6%	0.36 5.9%	1.16 16.4%
Waiting and relaxation	1.62 18.8%	1.00 16.2%	0.80 13.3%	1.18 16.7%
Supervision	0.55 6.4%	0.30 4.9%	0.16 2.7%	0.35 5.0%
Extra breaks	2.27 26.3%	1.01 16.4%	1.49 24.8%	1.63 23.0%
Total lost of time (hours per week)*	8.64 21.6%	6.16 15.4%	6.02 15.1%	7.07 17.7%

Note * assumed 40 hours working time.

5.3 The Productivity Problems

The Craftsmen Questionnaire Survey Technique has established that construction operatives know more about their productivity problems than any other individual (see Sebastian and Bocherding, 1979). Craftsmen (bricklayers, carpenters, and steel fixers) were asked to indicate whether or not identified problems existed on their site and to estimate hours lost due to them.

Results of this section of the questionnaire revealed that construction craftsmen, working on high-rise buildings would on average lose about 8 hours per 40 hours working week (20%), with steel fixers losing 8.46 hours, bricklayers losing 8.26 hours, and carpenters losing 7.30 hours (see Table 5.13).

Table 5.13 Hours Lost and Severity Ranking of the On-site Productivity Problems.

On-site	Bricklayers		Carpenters		Steelfixers	
Productivity Problems	Hours	Rank	Hours	Rank	Hours	Rank
Lack of material	1.69	3	3.51	1	2.25	1
Lack of tools	0.23	8	0.32	5	1.21	3
Equipment breakdown	0.56	5	0.08	9	0.67	6
Rework	1.70	2	2.03	2	1.00	4
Changing of workers	0.38	6	0.11	7	0.00	10
Interference	0.62	4	0.37	4	2.04	2
Absenteeism	2.38	1	0.56	3	0.85	5
Supervision delays	0.20	10	0.19	6	0.02	9
Changing of foremen	0.03	11	0.00	11	0.00	10
Too much work	0.23	8	0.10	8	0.33	7
Over crowded	0.24	7	0.03	10	0.09	8
Total hours lost	8.26		7.30		8.46	

The main productivity problems to bricklayers are 1). 'absenteeism', 2). 'rework' 3). 'lack of material'. To carpenters: 1). 'lack of material', 2). 'rework', and 3). 'absenteeism'. To steel fixers: 1). 'lack of material' , 2). 'interference', and 3). 'lack of tools'.

In order to test agreement of the severity of productivity problems amongst the three different trades, Kendall concordance analysis was carried out (see Kinnear, and Gray, 1994). The null hypothesis of the analysis was stated as: "there was no agreement between ranking of the problems by the three types of craftsmen". The test rejected the null hypothesis at the 99% level of significance implying that there was strong agreement of the productivity problems among the craftsmen. Furthermore, the analysis also gave an indication of the level of agreement at 80% (Coefficient of concordance W = 0.80). It can reasonably be concluded that the severity of productivity problems in the three different trades are almost the same. Any strategy aimed at solving the problems for any of the trades will equally work for the others. Let us now discuss the productivity problems (see Table 5.14).

Table 5.14 Overall Ranking of On-site Productivity Problems by Craftsmen.

On-site Productivity Problems	Mean rank	Rank order
Lack of material	1.67	1
Lack of tools	5.50	5
Equipment breakdown	6.67	6
Rework	2.67	2
Changing of workers	7.83	7
Interference	3.33	4
Absenteeism	3.00	3
Supervision delays	8.33	9
Changing of foremen	10.83	11
Too much work	7.83	7
Over crowded	8.33	9

cases	W	chi-square	DF	Significance
3	0.7994	23.9818	10	0.00765

5.3.1 Lack of Materials

Overall, this ranked the most important problem which is understandable since work cannot be done without the necessary materials. The average unproductive time caused by material unavailability for carpenters was 3.51 hours, for steel fixers 2.25 hours, and bricklayers 1.69 hours. In order to find the causes of this problem, the craftsmen were requested to rank a list of causes. This kind of data is easy to analyse using nonparametric statistics such as Friedman analysis (see Kinnear, and Gray, 1994). Results of the analysis are presented in Table 5.15. The rank orders were obtained from the mean ranks. The smaller the mean, the more important the cause. 'On-site transportation difficulty' was cited as 1st, 'Inadequate material storage' was 2nd, 'excessive paper work requests' 3rd, and 'Inadequate planning' 4th.

On-site transportation difficulties were cited as being the most significant problem. This is not surprising since most high rise buildings are constructed in densely populated urban areas making it difficult to distribute materials to the desired places when they are needed. 'Improper allocation of materials' or 'lack of material storage facilities' are also typical problems on urban high-rise construction sites. Material cost has been recognised as the highest cost component accounting for 65% of the overall construction cost of high-rise building in Indonesia (see Kaming, et.al., 1995a). It is for this reason that contractors have to be careful to manage materials effectively. In an attempt to control on-site utilisation of materials, the 27 projects studied are invariably overwhelmed by 'bureaucracy' with 'excessive paper work' leading to delays in material supplies to sites.

Table 5.15 Causes of Material Unavailability.

Causes of Material Unavailability	Bricklayers		Carpenters		Steelfixers		All Craftsmen	
	Mean Rank	Rank Order	Mean Rank	Rank Order	Mean Rank	Rank Order	Mean Rank	Rank Order
On-site transportation	2.36	1	1.95	1	1.35	1	1.92	1
Excessive paper works for request	2.73	3	2.60	3	3.09	3	2.78	3
Improper material storage	2.23	2	2.21	2	2.29	2	2.24	2
Inadequate planning	2.68	4	3.23	4	3.26	4	3.06	4
Cases	57		64		48		169	
Significant level	0.105		0.000		0.000		0.000	

5.3.2 Rework

Rework ranked the 2nd most important problem to craftsmen's productivity in Indonesia. Carpenters and bricklayers spend more time (almost double) reworking than steel fixers. The causes of rework are design changes, poor instruction, poor workmanship and complexity of the design specification ranking 1st, 2nd, 3rd, and 4th respectively. The three categories of trades ranked the causes of rework more or less the same (see Table 5.16).

Table 5.16 Causes of Reworks.

Causes of Rework	Bricklayers		Carpenters		Steelfixers		All Craftsmen	
	Mean Rank	Rank Order	Mean Rank	Rank Order	Mean Rank	Rank Order	Mean Rank	Rank Order
Poor instruction	2.35	2	2.35	2	2.34	2	2.38	2
Design changes	1.78	1	2.06	1	1.85	1	1.31	1
Poor worksmanship	2.72	3	2.42	3	2.83	3	3.02	3
Complex specification	3.14	4	3.17	4	2.99	4	3.29	4
Cases	78		75		56		209	
Significant level	0.000		0.000		0.000		0.000	

Table 5.17 An Evaluation of Methods to Avoid Reworks

	Bricklayers		Carpenters		Steelfixers		All Craftsmen	
Methods*	Mean Rank	Rank Order	Mean Rank	Rank Order	Mean Rank	Rank Order	Mean Rank	Rank Order
Detail and clear drawing.	2.06	3	2.37	3	2.30	3	2.23	3
Clear & written instruction.	1.92	1	1.93	2	1.97	2	1.94	2
Briefing for every start a new job.	2.02	2	1.70	1	1.73	1	1.84	1
Cases	93		81		66		240	
Significant level	0.615		0.000		0.005		0.000	

Note: * Other methods had been cited by craftsmen but not included in the analysis.

Design changes lead to poor productivity. The causes of design changes were not specially examined in this study but the reader can refer to Stewart, (1989) and Construction Management Committee of the ASCE Construction Division (1991) for detailed analysis of causes of design changes. Unclear and poor instructions can be due to communication problems caused by poor instruction procedures or lack of understanding by the craftsmen. Poor workmanship which ranked third can also be caused by unclear instruction. The more complex the design the more the rework.

Part of the questionnaire consisted a list of effective ways to eliminate the causes of reworks. Craftsmen were asked to rank the effectiveness of them on a 5-point scale, i.e. 5 (very effective) to 1 (very poor) (See Table 5.17 for results). 'Briefing on every new activity' was considered the most effective way; 'clear instruction in a written form' the second; and 'detailed construction drawing' the third.

5.3.3 Absenteeism

Olomolaiye (1988) found that this problem ranks 5th in both the USA and the UK and 6th in Nigeria. In Indonesia it was rated 3rd. Being a well recognised problem, contractors try to solve it by providing accommodation for workers on site in order to monitor them. Indeed, about 65% of the workers surveyed were accommodated on sites. Note that absenteeism was ranked most severe problem (see Table 5.13) and the most notorious (see Table 5.18) by the bricklaying group.

Table 5.18 How Craftsmen Quit their Job.

	Number and Percentages of Craftsmen			
Quit the job	**Bricklayers**	**Carpenters**	**Steelfixers**	**Total**
Voluntary quitting	44	22	22	88
	47.3%	27.2%	33.8%	36.8%
Dismissed by employer	49	59	43	151
	52.7%	72.8%	66.2%	63.2%

An investigation of labour turnover is presented in Table 5.19 and reveals that the main causes are: 1). 'Not enough work on-site'; 2). 'Better pay from other projects' 3). 'Distances from home to site'; 4). 'Better working environment for instance better on-site safety'; and 5). 'More challenging works or other career development on other projects'. The ranking provided by each trade and overall by the craftsmen using Friedman ranking test was in the same order at 95% significance level.

Table 5.19 Reasons for Quitting a Job.

Reason for quitting a job	Bricklayers		Carpenters		Steelfixers		All Craftsmen	
	Mean Rank	Rank Order	Mean Rank	Rank Order	Mean Rank	Rank Order	Mean Rank	Rank Order
Better pay from other project	1.82	2	2.08	2	2.17	2	1.93	2
Nearer distance from home	3.64	3	3.42	3	2.50	3	3.33	3
Challenging job on other site	4.25	5	4.67	5	4.67	5	4.41	5
Better working environment on other site	4.18	4	3.5	4	4.33	4	4.02	4
Not enough job	1.29	1	1.33	1	1.33	1	1.30	1
Cases	14		6		3		23	
Significant level	0.000		0.003		0.042		0.000	

5.3.4 Interference

Interference between gangs and workers is caused by mismanagement of the work sequence, and was ranked fourth by Indonesian workers. Steel fixers suffer more of this problem. Perhaps they are more dependent on other trades. For instance the steel fixers have to wait before fixing the reinforcement rods if the carpenters have not completed the formworks. Interference can also be caused by unbalanced gang sizes. An investigation towards balancing present gang sizes (craftsman over his helpers) against the ideal (based on craftsmen perception) was carried out. The results are presented in Figure 5.1. Thirty five percent of craftsmen prefer a gang size of one helper to one craftsman with only 28.4% of this type on sites surveyed. Thirty five percent of the craftsmen would expect 2 helpers; 22% were of this type on sites. Twenty five percent of craftsmen claimed that for every 5 craftsmen only one helper was provided by the site management. Some of the imbalances are caused by absenteeism. Attempts to balance gangs by management include substituting absent helpers with new crews. Remarkably, the majority of craftsmen were satisfied with this substitution.

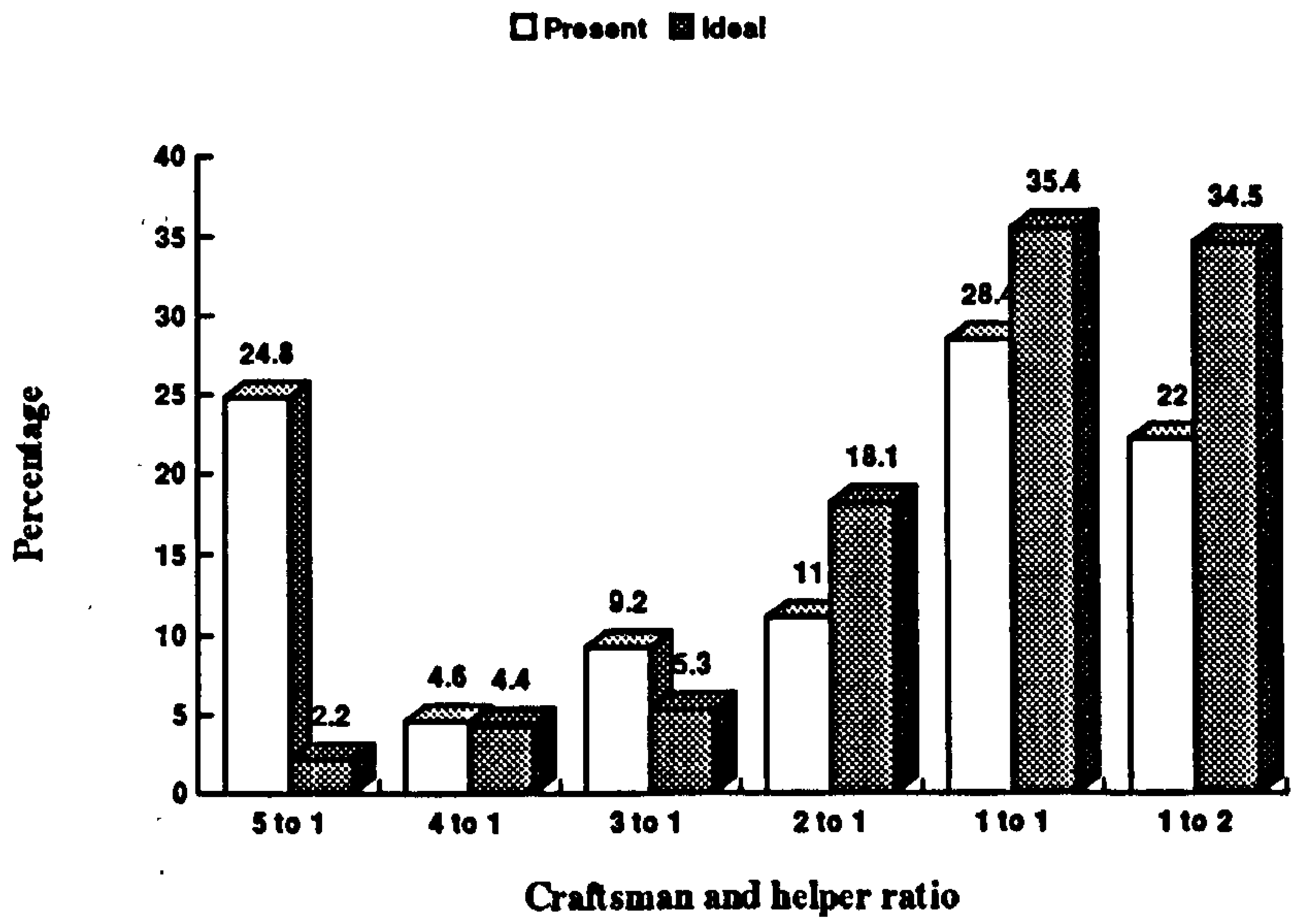

Figure 5.1 Comparison of Craftsman - Helper Ratio.

5.4 Evaluation of Production Output, Time Spent Working Productively, and Skill

5.4.1 Performance and Skill

An additional investigation to quantify craftsmen's performance and skill was undertaken during the survey. Craftsmen's supervisors and foremen were requested to state target output before observation with actual output measured after completion. Both target and actual outputs are compared to give an indication of performance. In order to be able to compare the performance of the different trades, the quantitative measure of performance is defined as the percentage of actual against targeted output.

Foremen were also asked to assess their craftsmen's skill using the 5 skill measures recommended by Bowie and Lupton (1973). According to them, skill (Y_s) is defined as a function of 5 variables: $Y_s = f(X_1, X_2, X_3, X_4, X_5)$; where, (X_1) = experience in type of works being carried out; (X_2) = education background and training; (X_3) = accuracy/precision of the results of their works; (X_4) = achievement of their targeted output from the commutative past records; and (X_5) = dexterity of the craftsmen in working. These variables were rated on a 5 point scale (1 very poor to 5 very good) for each of the craftsmen selected for the survey. Responses from each craftsmen were totalled and divided by 25 (5 x 5 = maximum score attainable) to convert to a 'skill index' for each worker.

For example, if a bricklayer was assessed by his direct supervisor on the five skill variables: the craftsman had worked with him for more than 3 years ($X_1 = 3$), was from a junior high school then $X_2 = 4$, almost never made mistakes $X_3 = 5$, results of work carried out by the craftsman was often higher than others, $X_4 = 4$ is only good in a small scope of bricklayer's work $X_5 = 3$. Therefore, the craftsman's skill index from his supervisor's assessment was 0.76 (= 19 / 25). Note that the general guideline for both X_1 and X_2 are set on a 5-scale category. For instance, A high junior trade school graduate or equivalent is ranked 5, preliminary trade school graduate and equivalent is ranked 4, junior intermediate school graduate is ranked 3, preliminary school graduate is ranked 2, and not attained any certificate at all ranked 1 for X_1. Craftsmen with work experience more than 10 years is ranked 5, 5 to 10 year is ranked 4, 3 to 5 years is ranked 3, 1 to 2 years is ranked 2, and less than 1 years is ranked 1 for X_2.

Table 5.20 summarises the results of the activity sampling and provides the performance and skill indices. On average, Indonesian craftsmen spend about 75% of their time working productively. Their actual outputs are about 87% of targeted output. Their skill level is considered medium by their foremen indicated by skill index of 0.68 (0.00 = very poor to 1.00 = outstanding).

Table 5.20 Results from Activity Sampling of the Project Surveyed.

Project Identification	**Working Time***	**Output Index****	**Skill Index*****
1	0.78	1.00	0.74
2	0.78	0.87	0.60
3	0.75	0.52	0.60
4	0.77	0.92	0.61
5	0.78	0.88	0.59
6	0.81	0.82	0.63
7	0.84	1.11	0.69
8	0.75	1.00	0.65
9	0.79	0.92	0.64
10	0.80	0.88	0.72
11	0.75	0.80	0.63
12	0.78	0.90	0.67
13	0.88	1.03	0.72
14	0.76	0.81	0.70
15	0.69	0.75	0.68
16	0.77	0.90	0.60
17	0.75	0.90	0.66
18	0.72	0.97	0.63
19	0.75	0.78	0.69
20	0.77	0.78	0.63
21	0.74	0.85	0.68
22	0.75	0.95	0.69
23	0.72	0.95	0.74
24	0.65	0.82	0.68
25	0.63	0.77	0.72
26	0.70	0.87	0.71
27	0.68	0.74	0.72
Average	**0.75**	**0.87**	**0.67**

Note : £ 1 = Rp 3500 in 1995;

* Percentage of working time to total time;

** Percentage of actual output to target output;

*** Skill index ranges from 0 (poor) to 1(excellence).

To test if the three trades craftsmen working time, actual outputs, and skill levels are different from each other, one way analysis of variances was carried out. Result from ANOVA did not prove significant differences working time in the 3 trades. Similarly, it also indicated that the 3 trades actual outputs are not significantly different. On the other hand, craftsmen's skill was significantly different amongst the three trades with steel fixers 1st (skill index = 0.72), followed by carpenter 2nd (0.67) and bricklayer 3rd (0.62).

5.4.2 Relationship of Actual Outputs , Working Times, and Craftsmen's Skill

A correlation analysis was conducted to investigate the relationship of actual output, productive time spent by craftsmen and their skill. The results indicate that productive time and performance output were significantly correlated with a coefficient (Rs) of 0.30.

5.4.3 Comparison of Productivity Problems with Other Countries

In order to compare productivity problems with other countries obtained from literature, a re-arrangement for congruency of the factors of the present study with previous researchers was carried out and presented in Table 5.21.

Table 5.21 Hours lost due to Productivity Problems.

On-site Productivity Problems	Bricklayers		Carpenters		Steelfixers		Average	
	Hours	Rank	Hours	Rank	Hours	Rank	Hours	Rank
Lack of material	1.69	3	3.51	1	2.25	2	2.48	1
Lack of equipment	0.79	5	0.40	5	1.88	3	1.02	5
Interference	1.50	4	0.61	4	2.46	1	1.52	3
Absenteeism	2.38	1	0.56	3	0.85	5	1.26	4
Supervision delays	0.20	6	0.19	6	0.02	6	0.14	6
Rework	1.70	2	2.03	2	1.00	4	1.58	2
Total hours lost	8.26		7.30		8.46		8.01	

Overall, the ranking of productivity problems in the Indonesian construction industry is similar to those of other countries with 'lack of material' ranked 1st, 'rework' 2nd, interference 3rd, and absenteeism 4th.

Table 5.22 Comparison of Productivity Problems with Other Countries.

On-site Productivity Problems	Indonesia°	Nigeria*	UK*	USA*
	Rank	Rank	Rank	Rank
Lack of material	1st	1st	1st	1st
Lack of equipment	5th	3rd	5th	2nd
Interference	3rd	6th	2nd	5th
Absenteeism	4th	5th	6th	6th
Supervision delays	6th	4th	4th	4th
Rework	2nd	2nd	3rd	3rd

Note: ° This survey, * After Olomolaiye, (1988)

Since the ranking of problems in the present study was based on time lost due to productivity problems using an interval scale and, the previous study was ranked on an ordinal scale which produced relative indices for each of the factors, a rigorous analysis could not be performed. However, at a quick glance, results of this comparison in Table 5.22 show that the construction sites in four countries considered 'lack of material' a universal problem for both developed and developing countries. Rework was cited as second in developing countries, whilst developed countries cited this problem 3rd. This indicates different level of importance amongst productivity problems in developed and developing countries. Therefore, strategies for improvement are likely to be different.

Compared to Nigeria, the UK and the USA 'lack of material' is a universal problem affecting site productivity. Whilst more emphasis was given to rework problems in Indonesia and Nigeria, the UK and the USA were more concerned with interference and tool and management problems. It would appear that Indonesian craftsmen are better disciplined on time (see Olomolaiye, 1987). Time spent working by craftsmen in Indonesia has been found to be relatively higher than those of Nigeria and the UK; although this does not translate to higher productivity mainly because of a lack of skill. The Government and the other major construction industry participants in Indonesia now need to give urgent and serious thought to education and training of construction craftsmen.

5.5 Evaluation of Craftsmen's Motivation

It has been found in developed countries such as the United States that construction productivity has steadily declined over the last decade (Stokes, 1980; DoE, 1995). Work sampling surveys in USA have found productive time lost of 32 - 46.5% of the working day (Laufer, 1980). Similar survey carried out in Nigeria also indicated that major trades (bricklayers, joiners, and steel fixers) spent only 50% of their time working productively (Olomolaiye.et.al, 1987). With labour costs constituting between 25 - 40% of the total project cost, reduced labour costs present a great potential source of increased efficiency (Laufer and Jenkins, 1982). The motivation of labour force is of paramount importance as it is the initiator of human performance at work.

Construction operatives in Indonesia face unique problems many of which are unlike those experienced by their counterparts in developed countries (on which most motivation studies have been concentrated). Their construction environment is different in terms of site organisation, quality of supervision and availability of production resources. So also is their socio-economic environment. These attributes produce a different worker; and therefore perhaps motivated by different factors. But how do Indonesian construction operatives compare to other developing countries, such as Nigeria where operative motivation studies have been conducted? (see Olomolaiye and Ogunlana, 1988).

The main on-site productivity problems of construction operatives in Indonesia have been identified as 'lack of material' due to shortage or inadequate material planning, 'rework' due to design changes or unclear instructions, 'interference' of workers, and 'absenteeism'. Operatives in the industry in the construction industry are constantly in a dilemma of choosing between: migrating from the industry or: having to cope with continuos construction related problems. Furthermore, a range of other influences affect the intensity with which construction operatives work. Although difficult to quantify, it is possible to determine what these influences are and, their relative importance in motivating operatives to work. Such exercise will help in seeking ways to harness the productive capacity of construction workers in Indonesia. We may summarise the objectives of the craftsmen's motivation study as being to:

1. identify the most influential motivation and demotivation factors as well as their impact on Indonesian construction operatives;
2. rank the importance of such factors;
3. gauge operatives' satisfaction on their present sites; and
4. compare Indonesian craftsmen's motivation levels with those of other countries.

5.5.1 Craftsmen's Motivation

Tables 5.23, 5.24, 5.25, and 5.26 exhibit results of relative indices as well as ranking of motivating variables by all Indonesian craftsmen, bricklayers, carpenters, and steelfixers according to importance, and gratification. Importance ranks express the cumulative experience of workers of a variable as a motivator. The gratification ranks indicate the real motivation level of the workers at the time they were surveyed. The results indicate that motivational variables perceived as importance are well gratified. There is a significant of rank correlation coefficient of 0.831 between importance and gratification of the motivation factors. The five most important factors were: (1) fairness of pay; (2) good relation with workmate; (3) over-time payment; (4) bonus; and (5) good safety programme. Carpenters have the highest correlation coefficient (Rs = 0.918) indicating that they are likely to have better motivation compared to other two trades (Bricklayer Rs = 0.776, Steelfixer Rs = 0.775).

Table 5.23 Ranking of Craftsmen Motivation Factors According to Importance and Gratification.

No	Motivation Factors	Importance		Gratification	
		Relative Indices	Ranking	Relative Indices	Ranking
1	Good relations with mates.	0.858	2	0.779	1
2	Good safety programmes	0.798	4.5	0.670	3
3	The work itself	0.735	12	0.611	8
4	Over time	0.800	3	0.661	4
5	Fairness of pay	0.875	1	0.734	2
6	Recognition on the job	0.723	13	0.527	11
7	Accurate description of work to be done	0.730	10	0.618	7
8	Participation in decision making.	0.680	14	0.415	14
9	Good supervision.	0.778	7	0.660	5
10	Promotion.	0.763	8	0.486	13
11	More responsibility.	0.745	9	0.580	9
12	Challenging task	0.658	15	0.417	15
13	Job security.	0.780	6	0.643	6
14	Choosing workmates	0.728	11	0.522	12
15	Bonus.	0.798	4.5	0.547	10

Spearman Rank Correlation Coefficient (Rs) = 0.831

2 Tailed Significance (P) = 0.000

Table 5.24 Ranking of Bricklayer Motivation Factors According to Importance and Gratification.

No	Motivation Factors	Importance		Gratification	
		Relative Indices	Ranking	Relative Indices	Ranking
1	Good relations with mates.	0.825	2	0.730	1
2	Good safety programmes	0.755	4.5	0.658	4
3	The work itself	0.695	13	0.581	8
4	Over time	0.750	6	0.660	3
5	Fairness of pay	0.853	1	0.701	2
6	Recognition on the job	0.700	11	0.524	12
7	Accurate description of work to be done	0.700	12	0.615	7
8	Participation in decision making.	0.658	14	0.440	14
9	Good supervision.	0.738	7	0.633	5
10	Promotion.	0.723	9	0.497	13
11	More responsibility.	0.725	8	0.571	10
12	Challenging task	0.628	15	0.365	15
13	Job security.	0.755	4.5	0.632	6
14	Choosing workmates	0.705	10	0.561	11
15	Bonus.	0.780	3	0.576	9

Spearman Rank Correlation Coefficient (Rs) = 0.776
2 Tailed Significance (P) = 0.001

Table 5.25 Ranking of Carpenter Motivation Factors According to Importance and Gratification.

No	Motivation Factors	Importance		Gratification	
		Relative Indices	Ranking	Relative Indices	Ranking
1	Good relations with mates.	0.860	2	0.793	1
2	Good safety programmes	0.818	4	0.685	3
3	The work itself	0.780	5	0.668	5.5
4	Over time	0.835	3	0.668	5.5
5	Fairness of pay	0.898	1	0.778	2
6	Recognition on the job	0.748	11	0.593	10
7	Accurate description of work to be done	0.773	7	0.678	4
8	Participation in decision making.	0.668	14	0.374	15
9	Good supervision.	0.768	9	0.663	7
10	Promotion.	0.745	13	0.433	14
11	More responsibility.	0.773	7	0.625	9
12	Challenging task	0.663	15	0.455	13
13	Job security.	0.780	5	0.650	8
14	Choosing workmates	0.748	12	0.522	11
15	Bonus.	0.760	10	0.501	12

Spearman Rank Correlation Coefficient (Rs) = 0.918
2 Tailed Significance (P) = 0.000

Table 5.26 Ranking of Steelfixer Motivation Factors According to Importance and Gratification.

No	Motivation Factors	Importance		Gratification	
		Relative Indices	Ranking	Relative Indices	Ranking
1	Good relations with mates.	0.895	1	0.828	1
2	Good safety programmes	0.830	6	0.668	4
3	The work itself	0.733	11	0.584	7
4	Over time	0.825	7	0.653	5
5	Fairness of pay	0.880	2	0.727	2
6	Recognition on the job	0.728	12	0.449	13
7	Accurate description of work to be done	0.718	14	0.552	9
8	Participation in decision making.	0.725	13	0.428	15
9	Good supervision.	0.840	4	0.691	3
10	Promotion.	0.838	5	0.534	11
11	More responsibility.	0.740	9	0.540	10
12	Challenging task	0.695	15	0.442	14
13	Job security.	0.808	8	0.650	6
14	Choosing workmates	0.735	10	0.469	12
15	Bonus.	0.863	3	0.560	8

Spearman Rank Correlation Coefficient (Rs) = 0.775

2 Tailed Significance (P) = 0.001

5.5.1.1 Fairness of Pay

This factor was considered the greatest motivator with importance relative index of 0.875. Although operatives are often unhappy about their level of pay and managers/employer are always complaining about operatives' low productivity. Despite Herzberg's (1968) argument that money is not a satisfier (and as a result not a motivator), this survey coupled with previous works (Neale, 1979; Mackenzie and Harris, 1984; and Price, 1992) confirm that money is a powerful motivator of construction workers. In summary, low pay is a source of discontent to many Indonesian construction operatives.

5.5.1.2 Good Relation with Workmates

This is considered by operatives surveyed as the 2nd most important motivation factor. with a relative importance index of 0.858. Response was similar amongst the three trades and indicate that this factor was well gratified on the sites. In a multi-cultural society such as Indonesia, establishing good relationship among workmates can be of great advantage if well utilised.

5.5.1.3 Overtime Payment

This was ranked 3rd on importance scale by all construction operatives with an index of 0.800. The importance of this variable was ranked 6th, 3rd, and 7th by bricklayers, carpenters, and steelfixers respectively. Only carpenters are not gratified with their overtime payment - see Tables 5.24, 5.25, and 5.26. If overtime is used judiciously and controlled closely; it can be a great source of motivation for operatives (see Warren, 1989). As practised in developed countries (see Horner & Talhouni, 1995), overtime was originally set up for a gang to catch up with the schedule. There may be situations in which operatives are forced to work outside normal working hours, especially when the project is behind schedule, and there is no other alternative but to initiate overtime working. Because of the increase time at work there is a chance for increased earning, hence it's motivating influence.

5.5.1.4 Bonus

The effectiveness of financial incentive programmes for construction workers has been proved by many researchers. Laufer's (1980) findings indicate that financial incentive programmes for construction labour could materially raise productivity, lower overall production cost, shorten construction time, improve quality of management, and increase the earnings of the workers and hence satisfaction levels! Price (1992) claims that the introduction of a financial incentive can improve site productivity threefold. Although the effectiveness of the variable is without doubt to many, proper application and utilisation is very important. Bonuses ranked 5th on the importance scale in this survey but rarely gratified on the sites (10th).

5.5.1.5 Good Safety Programme

By their very nature, most construction works are prone to accidents. Operatives *do* care about the provision of health and safety at work. This motivator was ranked 5th with a relative importance index of 0.798 reflecting the importance attached with it being well gratified on the sites surveyed which may be due to the positive safety regulations imposed on construction sites by the Indonesian Ministry of Labour (see Harijanto, 1993).

5.5.2 Craftsmen's Demotivation

Demotivating factors are not necessarily the exact opposite (i.e., converse) of motivating factors. Most demotivators originate from apparent trivial causes, yet their impact is often significant (see Borcherding and Garner, 1981). Demotivators are those factors that if found on a project, cause frustration, disappointment and dissatisfaction. In this survey 12 factors with de-motivating effect were selected from literature and operatives were asked to rank their perceived importance and their level of gratification on their *present* working environment. Tables 5.27, 5.28, 5.29, and 5.30 exhibit results of relative importance indices and gratification rankings of demotivation factors for all craftsmen, bricklayers, carpenters, and steelfixers respectively. The five most important demotivating variables are now discussed:

Table 5.27 Ranking of Craftsmen Demotivation Factors According to Importance and Gratification.

No	Demotivation Factors	Importance		Gratification	
		Relative Indices	Ranking	Relative Indices	Ranking
1	Disrespectful supervisior	0.823	1	0.516	3
2	Little accomplishment	0.815	2	0.608	1
3	Discontinuity of work	0.753	4	0.522	2
4	Lack of recognition.	0.713	6.5	0.450	7
5	Under-utilisation of skill	0.675	10	0.392	12
6	Incompetence of workmates	0.700	9	0.414	10
7	Lack of co-operation among craftsmen	0.785	3	0.512	4
8	Poor Instruction programme	0.713	6.5	0.426	8
9	Unsafe condition	0.745	5	0.469	6
10	Productivity urged but no one cares	0.648	12	0.404	11
11	Hot weather.	0.705	8	0.487	5
12	Not enough work.	0.660	11	0.416	9

Spearman Rank Correlation Coefficient (Rs) = 0.886
2 Tailed Significance (P) = 0.000

Table 5.28 Ranking of Bricklayers Demotivation Factors According to Importance and Gratification.

No	Demotivation Factors	Importance		Gratification	
		Relative Indices	Ranking	Relative Indices	Ranking
1	Disrespectful supervisior	0.808	2	0.490	2
2	Little accomplishment	0.833	1	0.621	1
3	Discontinuity of work	0.740	4	0.475	3
4	Lack of recognition.	0.705	6	0.433	5
5	Under-utilisation of skill	0.635	10	0.532	11
6	Incompetence of workmates	0.685	8	0.388	9
7	Lack of co-operation among craftsmen	0.755	3	0.438	4
8	Poor Instruction programme	0.703	7	0.392	8
9	Unsafe condition	0.720	5	0.415	6
10	Productivity urged but no one cares	0.603	12	0.371	10
11	Hot weather.	0.648	9	0.407	7
12	Not enough work.	0.610	11	0.348	12

Spearman Rank Correlation Coefficient (Rs) = 0.944
2 Tailed Significance (P) = 0.000

Table 5.29 Ranking of Carpenters Demotivation Factors According to Importance and Gratification.

No	Demotivation Factors	Importance		Gratification	
		Relative Indices	Ranking	Relative Indices	Ranking
1	Disrespectful supervisior	0.828	2	0.550	4
2	Little accomplishment	0.853	1	0.628	1
3	Discontinuity of work	0.778	4.5	0.593	3
4	Lack of recognition.	0.743	8	0.463	8
5	Under-utilisation of skill	0.715	9.5	0.413	11
6	Incompetence of workmates	0.750	7	0.438	10
7	Lack of co-operation among craftsmen	0.813	3	0.598	2
8	Poor Instruction programme	0.753	6	0.460	9
9	Unsafe condition	0.778	4.5	0.503	6
10	Productivity urged but no one cares	0.673	12	0.399	12
11	Hot weather.	0.715	9.5	0.513	5
12	Not enough work.	0.700	11	0.483	7

Spearman Rank Correlation Coefficient (Rs) = 0.768
2 Tailed Significance (P) = 0.004

Table 5.30 Ranking of Steelfixers Demotivation Factors According to Importance and Gratification.

No	Demotivation Factors	Importance		Gratification	
		Relative Indices	Ranking	Relative Indices	Ranking
1	Disrespectful supervisior	0.833	1	0.512	4
2	Little accomplishment	0.750	4	0.560	2
3	Discontinuity of work	0.740	6	0.501	6
4	Lack of recognition.	0.688	7	0.457	7
5	Under-utilisation of skill	0.685	8	0.422	11.5
6	Incompetence of workmates	0.663	12	0.422	11.5
7	Lack of co-operation among craftsmen	0.793	2	0.513	3
8	Poor Instruction programme	0.678	10.5	0.433	9
9	Unsafe condition	0.743	5	0.505	5
10	Productivity urged but no one cares	0.678	10.5	0.456	8
11	Hot weather.	0.778	3	0.567	1
12	Not enough work.	0.680	9	0.430	10

Spearman Rank Correlation Coefficient (Rs) = 0.860

2 Tailed Significance (P) = 0.00

5.5.2.1 Disrespectful Supervisor

Disrespectful behaviour by the supervisor has the highest demotivating effect on operatives with a relative index of 0.823. However, only very few operatives cited their present supervisors as being disrespectful. It would seem that there is good working relationship between the workers and their supervisors.

5.5.2.2 Little Accomplishment

Little accomplishment due to lack of worker participation in planning seemed to have a demotivating effect, the results suggest that this factor frequently occurs on site. Workers often felt they were not heeded or simply perceived as being "just a number." There is little, if any, recognition of good quality or productivity and often, operatives' suggestions are ignored. Furthermore, poor planning can cause rework and result in time lost for the workers, since the workers are paid based on work done. This perhaps help to explain why the factor was ranked 2nd on the importance scale by all craftsmen.

5.5.2.3 Lack of Co-operation Amongst Workmates

This factor was ranked 3rd by respondents with a relative index of 0.785 suggesting that it has a high demotivating effect on performance and satisfaction. On the gratification scale it was ranked 4th. Table 5.27 indicates that the management system of the construction projects surveyed for co-ordinating craftsmen from various sub-contractors is somehow poor. The overall dissatisfaction level indicates that management should pay more attention to this demotivator.

5.5.2.4 Discontinuity of work

While there has been a boom in construction activities in the country, workers still experience discontinuity of employment due to project completion, bankruptcy of contractors, better opportunities on other sites, promotion etc. The workers in this survey ranked it the 2nd least occurring demotivator on their current jobs. Operatives who are satisfied with their employers behaviour and working conditions will be unwilling to leave just for increased earnings. A sense of loyalty to employers remains reasonably high among some Indonesian construction workers.

5.5.2.5 Unsafe Working Conditions

The specific nature of construction work has made it vulnerable to risks of accidents and hazard. Although official reports on accidents are scarce, the findings of this survey suggests that operatives perceive it as an important demotivating factor being ranked 5th. The problem with unsafe working conditions is not always due to a lack of safety equipment, but are often caused by worker non-conformance to safety rules. It seems that operatives care very much about safety and reported the variable as their fourth highest demotivating factor within the project.

5.5.3 Motivation Band

Table 5.31 presents an example of the quantification of craftsman's motivation and demotivation as well as the total motivation indices adopted from a previous study (Olomolaiye, 1988). Based on this quantification, a motivation band can be established for all 243 craftsmen and, for each of the three trades.

Table 5.31 A Method of Quantifying Craftsman's Motivation (After Olomolaiye, 1988).

Motivation Factors	Pm	Um	Pm * Um	Demotivation Factors	Pd	Ud	Pd * Ud
1. Good relations with mates.	3	4	12	1. Disrespectful by supervisor	3	1	3
2. Good safety programmes	3	2	6	2. Little accomplishment	3	2	6
3. The work itself	3	2	6	3. Discontinuity of work	2	4	8
4. Over time	1	2	2	4. Lack of recognition.	2	1	2
5. Fairness of pay	3	2	6	5. Under-utilisation of skill	3	3	9
6. Recognition on the job	3	1	3	6. Incompetence of workmates	3	1	3
7. Accurate description of work to be done	2	2	4	7. Lack of co-operation amongst foremen	3	1	3
8. Participation in decision making.	3	3	9	8. Poor instruction	3	1	3
9. Good supervision.	3	2	6	9. Unsafe condition	2	1	2
10. Promotion.	-	-	-	10. Productivity urged but no one cares	2	1	2
11. More responsibility.	2	2	4	11. Hot weather.	3	1	3
12. Challenging task	3	3	9	12. Not enough work.	-	-	-
13. Job security.	1	1	1				-
14. Choosing workmates	3	2	6				
15. Bonus.	1	1	1				
	Σ Pm * Um =		75		Σ Pd * Ud =		44

Note: Pm = Importance of motivation factors, Um = frequency of occurrence the motivation factor.
Pd = Importance of demotivation factors, Ud = frequency of occurrence of the demotivation factor.

Motivation Index = 75 / 168 = 0.44 and Demotivation Index = 44 / 132 = 0.33

Figures 5.2, 5.3, 5.4 and 5.5 exhibit motivation bands for all craftsmen, bricklayers, carpenters, and steelfixers respectively. Note that the four figures demonstrate a similar pattern indicating that increases in motivation factors is always accompanied by decrease in demotivation. This is in line with the figurative cup with two taps, an inlet (motivating) and the other an outlet (demotivating) described by Olomolaiye, (1988) i.e., motivating craftsmen should be achieved by simultaneously improving motivating factors and eliminating demotivating factors. This is also supported by previous studies (see Borcherding, et.al., 1979; Borcherding & Garner, 1981) that improving worker motivation is, first, to reduce the effects of any existing demotivator and, then, possibly improve motivators. Simply introducing motivating factors will not always guarantee motivational improvement if significant demotivators are present.

5.5.4 Comparison with Other Countries

Similar studies (Olomolaiye & Ogunlana, 1988; Olomolaiye, 1988; Wilson 1979) evaluated the ranking of motivation influences for operatives in Nigeria, bricklayers in the UK, and craftsmen in the UK respectively. These provide an interesting focus for comparing the motivation of craftsmen/operatives in the three countries according to Maslow's motivation theory. Table 5.32 exhibits the overall ranking of the motivation factors of Indonesian, Nigerian, and UK workers.

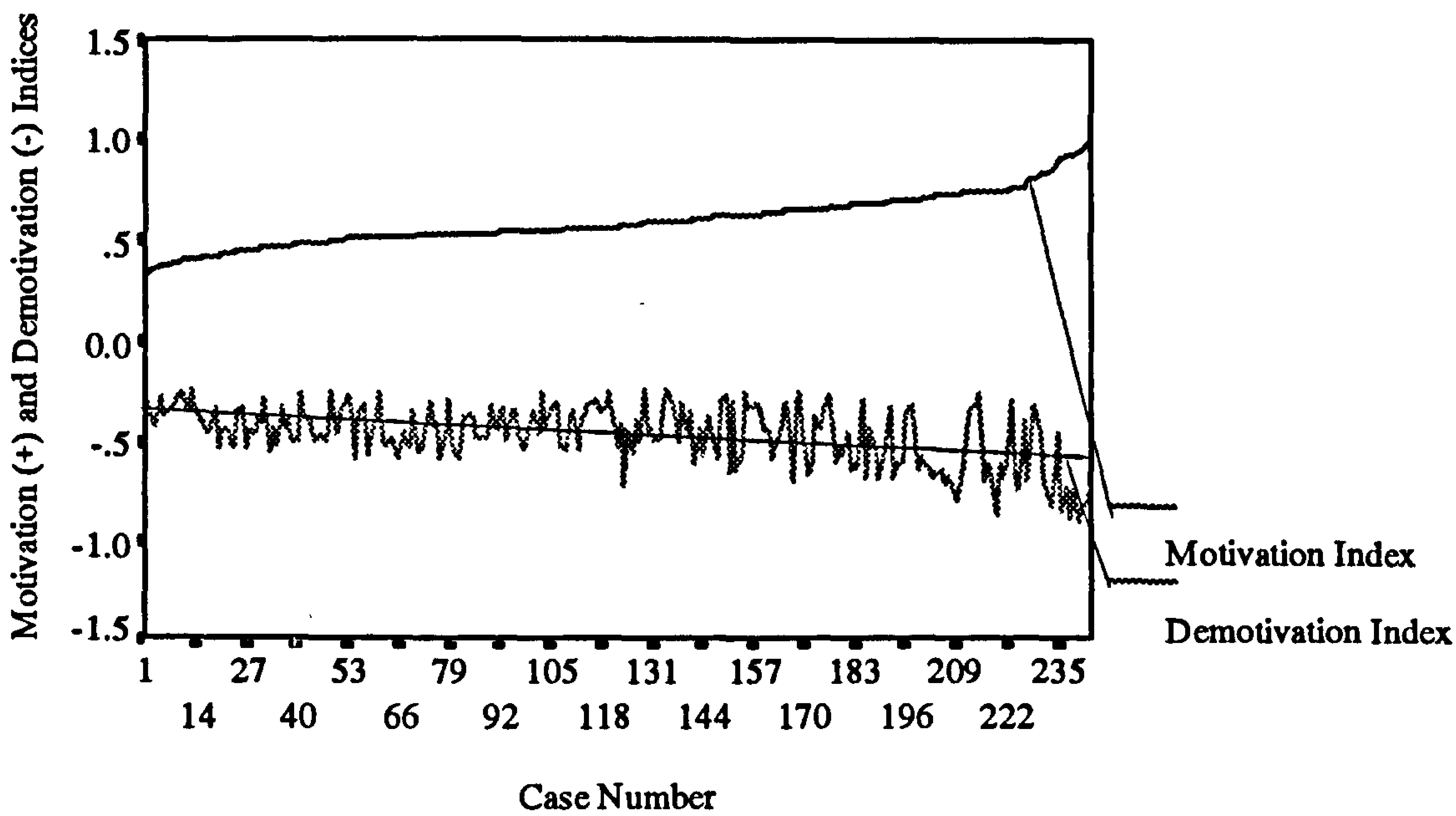

Figure 5.2 Motivation Band of All Craftsmen.

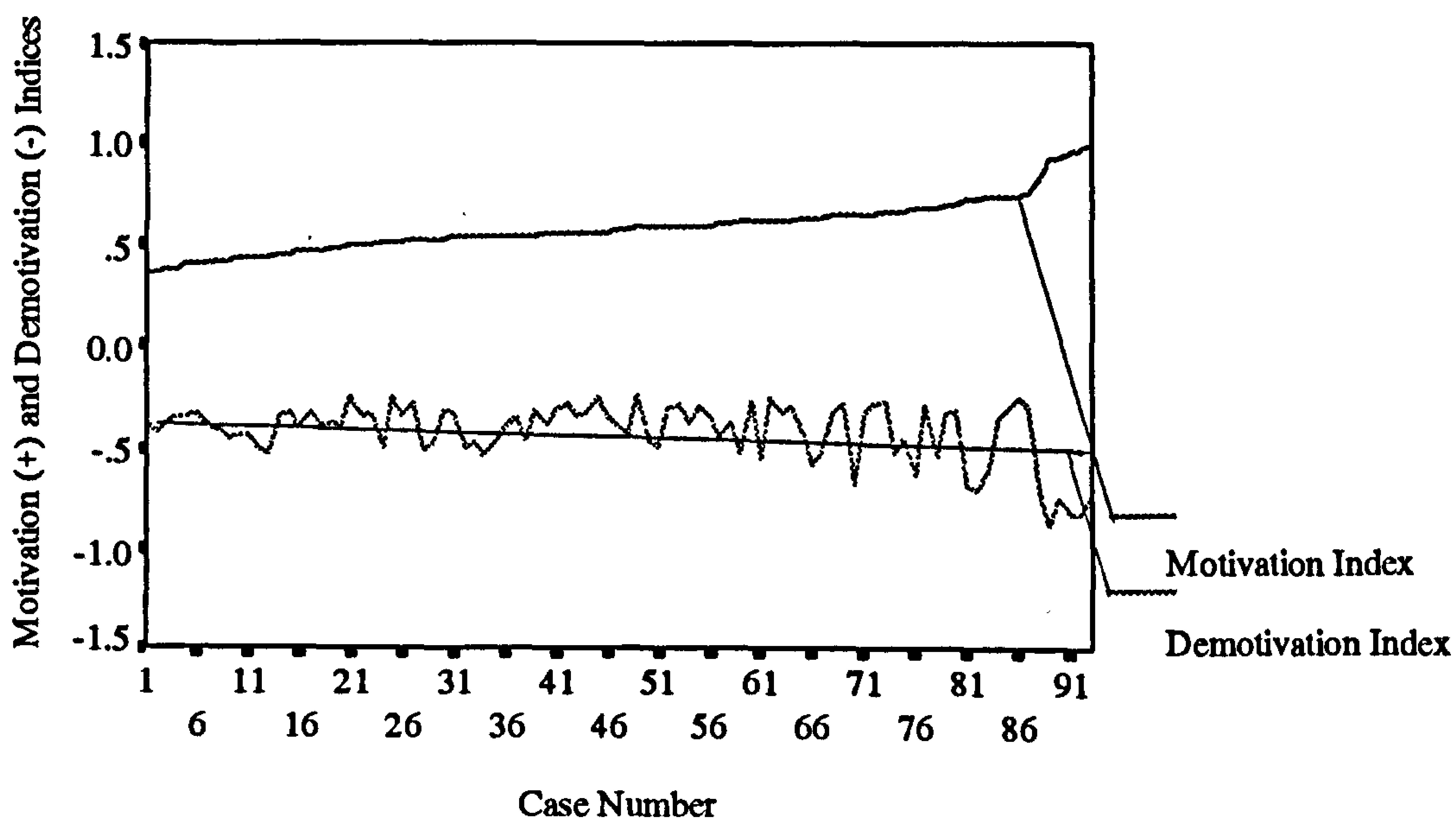

Figure 5.3 Motivation Band of Bricklayers

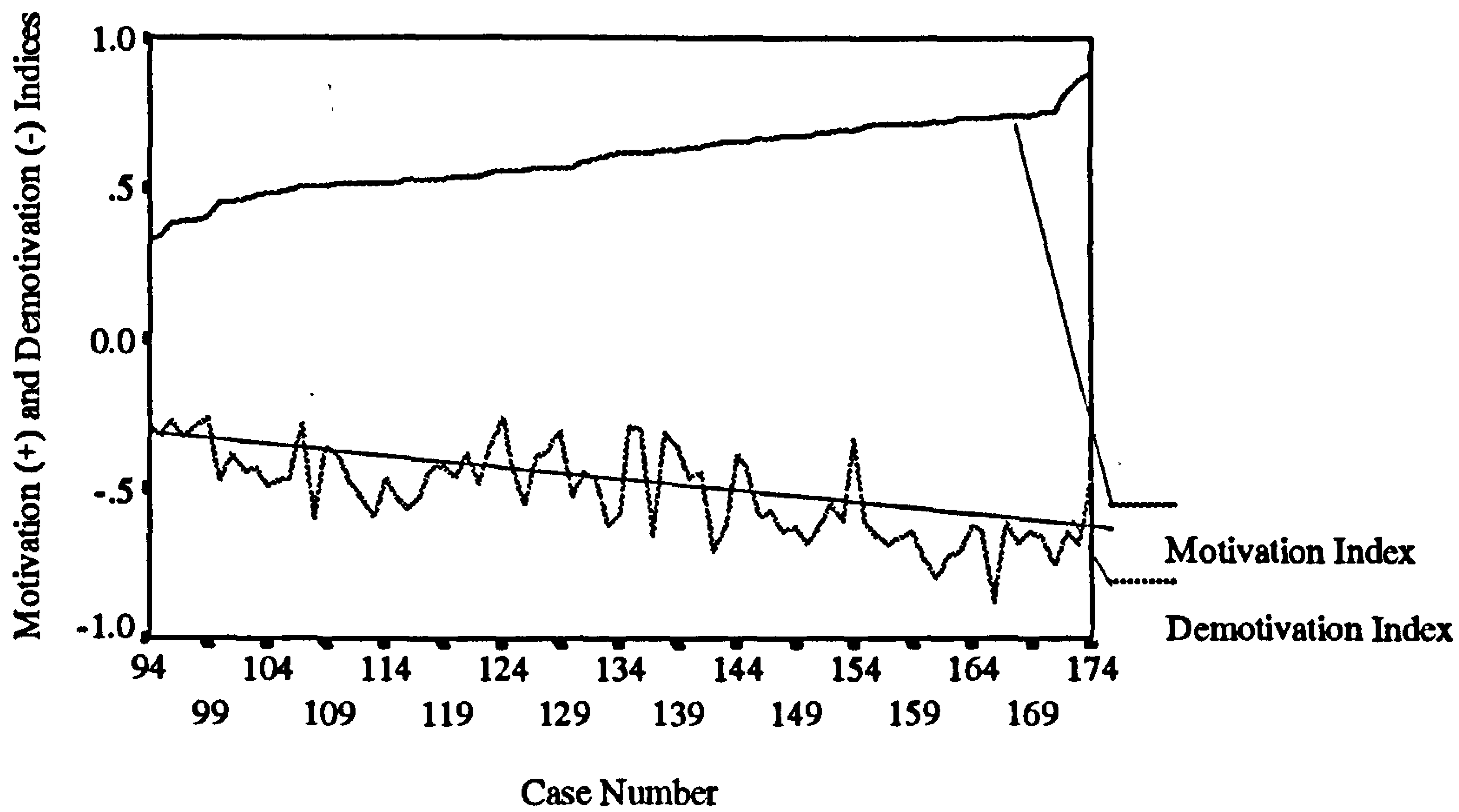

Figure 5.4 Motivation Band of Carpenters.

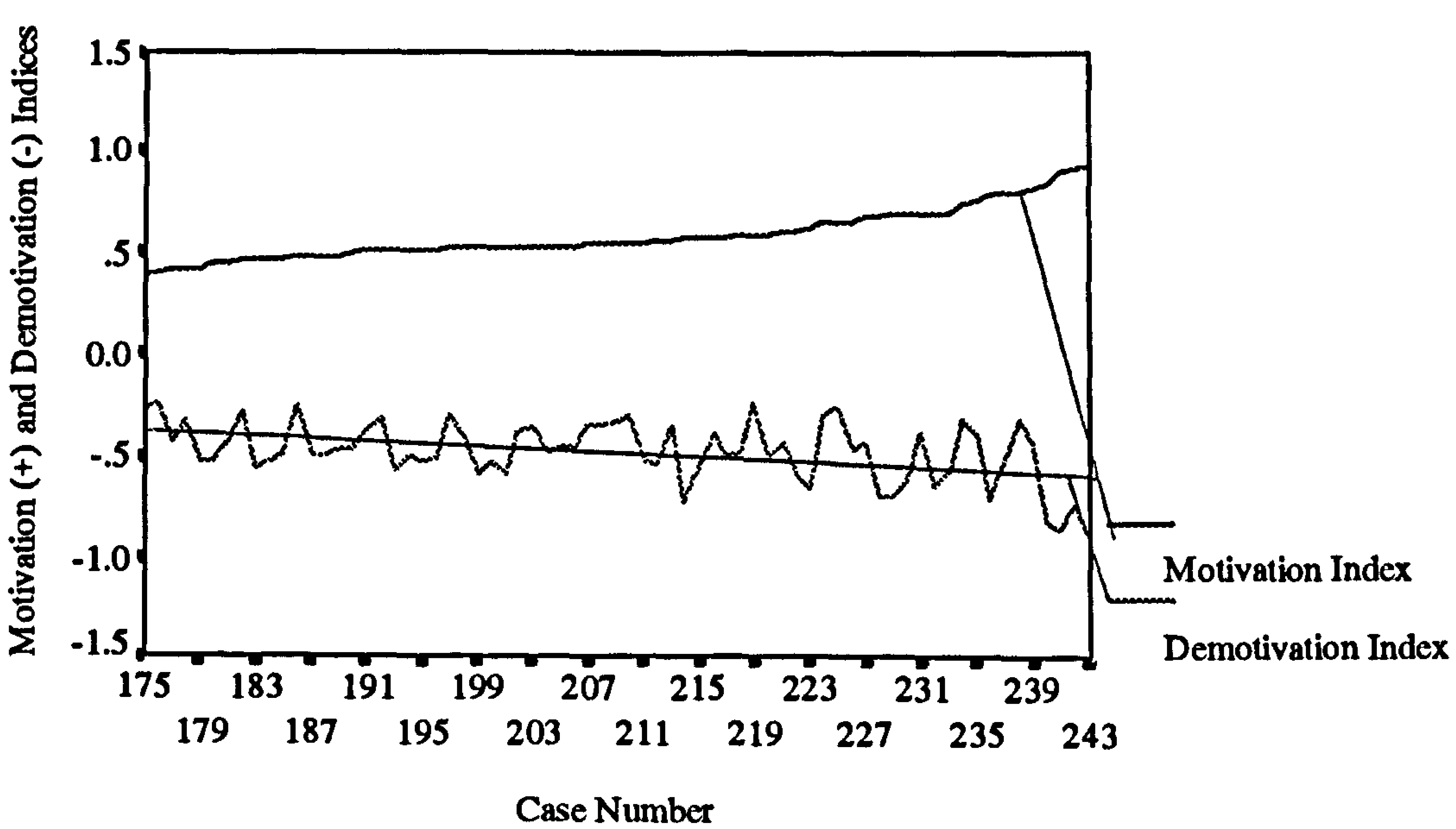

Figure 5.5 Motivation Band of Steel fixers

Table 5.32 Comparison of Motivation Ranking in Indonesia, Nigeria, and UK

Theoritical Ranking (After Maslow)	Indonesian Operative Ranking (In this survey)	Nigerian Operative Ranking (Olomolaiye & Ogunlana)	UK Bricklayer Ranking (Olomolaiye)	UK Operative Ranking (Wilson & Harris)
Physiological Needs				
Fairness of pay	1st		1st	
Overtime pay	3rd		15th	
Earnings Related (Fringe Benefit and Bonus)	4th	1st	5 th	3rd
Safety Needs				
Physical / Safety / Working conditions	5th	6th	8th	1st
Welfare conditions				2nd
Job security	7th	4th	6th	10th
Belonging Needs				
Good Relationship with mates	2nd	2nd	1st	4th
Good Orientation programme		8th		4th
Good Supervision	6th	9th	3rd	8th
Choosing workmates	10th		9th	
Need for Esteem				
More responsibility	9th		12th	
The work itself	11th		3rd	
Accurate description of work to be done.	12th		7th	
Recognition on the job	13th	5th	13th	7th
Need for Self Actualisation				
Promotion.	8th		14th	
Participation in decision making	14th	7th	10th	6th
Challenging job	15th	3rd	11th	9th

Concentrating on the highest ranked motivators quoted by the four sets of operatives, physiological needs were ranked highest; reflected in the ranking of similar earning related motivators in Nigeria. Although bricklayers in the UK ranked fairness of pay 1st, other earnings related variables were ranked low, especially, overtime pay. This tends to support Olomolaiye and Ogunlana assertion that craftsmen in the UK who have jobs can satisfy their basic needs because they earn sufficient money, whilst workers in Indonesia (perhaps also Nigeria) need to work extra hours to supplement their income. Furthermore, UK craftsmen were often in favour of shorter working hours with trades finishing early on Fridays or simply 'coasting' once the 'ceiling' of earnings' level had been reached.

In general, craftsmen in developing countries were found to be struggling on low wages as indicated by the higher ranking of *fairness of pay*, and preferred to *work overtime* as well as expect to earn *bonus*. Whilst bricklayers in the UK (Olomolaiye, 1988) indicated that *fairness of pay* (first hierarchy need) as paramount to motivation as well as *good relationship with workmate* (third hierarchy need). Although UK bricklayers ranked good relationship with mates the most important, it was generally ranked 4th by the UK operatives, whilst both Nigeria and Indonesian craftsmen ranked it 2nd. Generally, construction workers, enjoy working in a friendly environment, which can strengthen team spirit and collective bargaining powers when negotiating pay deals!

Another factor for comparison is job security. It was ranked 7th in Indonesia, 4th in Nigeria and 10th in the UK. Job security was ranked low in the UK perhaps because in the UK, contractors have paid particular attention to continuity, especially, towards the end of project as it is thought to be quite a powerful incentive to construction workers.

Differences between the ranking of motivation variables in the three countries are quite marginal suggesting that workers in both developed and developing countries have the same values for belonging, esteem and self actualisation.

5.6 Summary

It has been demonstrated that productive times often filter away in varying and significant degrees in Indonesia. Unproductive time was found to be 20% and 24.74% in the craftsmen questionnaire and activity sampling respectively. This loss of productive time was caused by a range of problems, identified in descending order as 'lack of material' (30.7%), 'rework' (20.1%), absenteeism (16.8%), 'lack of proper tools and equipment breakdown (12.2%), and 'interference' due to improper sequence of work and unbalanced gang sizes (11.8%).

The operatives responses to the questionnaire indicated the first five variables with highest motivating effect on Indonesian construction operatives in descending order as being:

1. Fairness of pay
2. Good relationship with workmates
3. Overtime payment
4. Bonus
5. Good safety programme.

The most demotivating factors affecting Indonesian construction operatives were found to be as follows:

1. Disrespect from supervisors
2. Little accomplishment
3. Lack of co-operation amongst mates

4 Discontinuity of work

5 Unsafe working conditions.

Level of payment is very important to operatives. In Indonesia there is no social security system as in most Western countries. The only income to the family is that which is earned. If by chance this income were insufficient or indeed stopped, the family would suffer. Indonesian operatives would find it difficult to survive on their current low wages if they were not allowed to work overtime.

The most successful method for improving work force motivation is to introduce motivating factors and to reduce the effects of any existing demotivating factors simultaneously. Simply introducing motivators will not always guarantee motivational improvement if significant demotivators remain. This could be done through the introduction of a performance appraisal system for assessing craftsmen with respect to compensation, i.e. setting a realistic level of remuneration for craftsmen based on their performance, without the need for overtime working, and support of bonus schemes. At the same time, efforts should be made to encourage co-operation amongst workmates, implement safety programmes, and reward craftsmen with job security.

The comparative study of craftsmen motivation found that craftsmen in developed countries have higher motivation needs than those from developing countries. In general, Indonesia craftsmen has similar characteristics with other developing countries. The common feature is that most of craftsmen in developing countries have little or no skill.

CHAPTER 6

CHAPTER 6

CONSTRUCTION PRODUCTIVITY PROBLEMS IN INDONESIA - A SURVEY OF FOREMEN

6.1 Introduction

Foremen are the hub of all construction works; their importance to project success cannot be overemphasised. Since their role *is* so important, it would prove useful to investigate their characteristics as a means of classifying them. Surveys of foremen have been carried out extensively in developed countries since Borcherding (1977) endeavoured to describe their functions and, how they themselves perceive their job. Lemna et.al (1986) examined the productivity characteristics of construction foremen and found that the hallmark of an efficient foreman was superior planning rather than superior team supervision. Maloney and McFillen (1987) investigated the influence of foremen factors on craftsmen performance; whilst Laufer and Shohet (1991a,b) compared foremen's activities and their span of control in both the USA and Israel. Only Yusof et.al (1990) has tried to explore the *characteristics* of foremen in developing countries.

The research herein reported aims at providing greater insights into how Indonesian foremen operate from various perspectives e.g., on-site practices, organisation, and productivity. The study proceeded on the premise that before normative behaviour of construction foremen can be ascertained a clear understanding of contextual situations in which they operate and how they actually *perform* their duties is required. In the first place this calls for descriptive studies, to be followed by diagnostic studies, that examine the effects of foremen upon craftsmen productivity.

Against this background, the authors firstly singled out for study the way in which first line supervisors of bricklayers, carpenters, and steel fixers carry out their work on

Indonesian construction sites. The selection of these particular trades is predicated by their primacy in building construction (see Olomolaiye, et.al. 1987).

We may therefore summarise the intentions of this chapter as being to:

(1) explore a number of important characteristics of foremen in Indonesia. These characteristics include employment, age, experience, training provision, and span of control;

(2) examine foremen's perception of current on site practices ;

(3) investigate time utilisation for construction activities by Indonesian foremen and compare with those from the United States and Israel reported in Laufer and Shohet (1991) ; and

(4) compare craftsmen productivity problems as identified by foremen with those identified through craftsmen questionnaire survey.

6.2 The Characteristics of Indonesian Foremen

Most Indonesian foremen are capable of supervising more than one trade. However, the sample was categorised into their respective trades i.e., depending on the work they were supervising at the time of the study. The resulting distribution was: 31 (38.3%) bricklaying, 26 (33.3%) carpentry , and 23 (28.4%) steel fixing trades respectively.

6.2.1 Employment

Table 6.1 presents the type of employers for which each of the foremen worked. Sixty four percent of the foremen worked for main contractors, 31% for 'labour only' sub-contractors, and the remainder for sub-contractors. Statistical distribution amongst the foremen was similar, with 60% of the steel fixing foremen working under the main contractors, and bricklaying foremen tending to work for 'labour only' sub-contractors than other employers.

Table 6.1 Categorisation of Foremen by Type of Employer

Worked under	Number and Percentage			
	Bricklaying Foremen	Carpentry Foremen	Steelfixing Foremen	Total Foremen
Sub-contractor Labour Only	11	8	6	25
	35.5%	29.6%	26.1%	30.9%
Sub-contractor	2	1	1	4
	6.5%	3.7%	4.3%	4.9%
Main contractor	18	18	16	52
	58.1%	66.7%	69.6%	64.2%

Table 6.2 Length of Stay with Direct Employer.

Length of employment (years)	Number and Percentage			
	Bricklaying Foremen	Carpentry Foremen	Steelfixing Foremen	Total Foremen
0 - 2	12	8	6	26
	38.7%	29.6%	26.1%	32.1%
2 - 5	7	9	8	24
	22.6%	33.3%	34.8%	29.6%
5 - 10	11	3	5	19
	35.5%	11.1%	21.7%	23.4%
10 - 20	1	6	3	10
	3.2%	22.2%	13.0%	12.3%
> 20	0	1	1	2
	0%	3.7%	4.3%	2.5%

The majority of foremen had been with their present employers for: less than 5 years (62%); less than 2 years (32%) and between 2 to 5 years (30%). Perhaps by virtue of being mostly employed by sub-contractors, bricklaying foremen have shorter lengths of stay with employers. Table 6.2 suggests that conversely, carpentry and steel fixing foremen tend to remain longer with their employers.

Table 6.3. presents the length of stay on their current projects where half of those surveyed had worked on their current projects for less than 3 months. Since most projects had only been in progress (on average) for about 4 months, it seems prudent to conclude that foremen had been on their current sites since inception or, since the time their respective trades were first introduced on the sites.

Table 6.3. Length of Stay on Current Projects.

	Number and Percentage			
Worked for present project (months)	**Bricklaying Foremen**	**Carpentry Foremen**	**Steelfixing Foremen**	**Total Foremen**
0 - 3	16	11	13	40
	51.6%	40.7%	56.5%	49.4%
3 - 6	7	12	5	24
	22.6%	44.4%	21.7%	29.6%
6 - 12	5	3	4	12
	16.1%	11.1%	17.4%	14.8%
> 12	3	1	1	5
	9.7%	3.7%	4.3%	6.2%

6.2.2 Age and Experience

Seventy two percent of the foremen were aged between 30 to 50 years, the distribution presented in Table 6.4 indicates some form of career development, with the 'middle aged' workman supervising those below 30 years. The fewer number of those aged above 50 suggests that most construction workmen would by then, have retired or have been promoted to higher management cadres. Indeed, previous research has shown that the optimum age band for site management tends to be within 30-40 years range (see Holt et.al, 1994).

Sixty percent of foremen have been in the industry for more than 10 years. Eleven percent had only been 2 to 5 years, these being mostly from the bricklaying trade, which does not require a long skill acquisition period.

Table 6.4 Age of Foremen Surveyed.

	Number and Percentage			
Age Groups (years)	**Bricklaying Foremen**	**Carpentry Foremen**	**Steelfixing Foremen**	**Total Foremen**
20 - 30	6	4	6	16
	19.4%	14.8%	26.1%	19.8%
30 - 40	14	13	6	33
	45.2%	48.1%	26.1%	40.7%
40 - 50	10	7	8	25
	32.3%	25.9%	34.8%	30.9%
> 50	1	3	3	7
	3.2%	11.1%	13.0%	8.6%

Table 6.5 Experience of Foremen.

Experience Groups (years)	Number and Percentage			
	Bricklaying Foremen	Carpentry Foremen	Steelfixing Foremen	Total Foremen
2 - 5	4	3	2	9
	12.9%	11.1%	8.7%	11.1%
5 - 10	8	9	6	23
	25.8%	33.3%	26.1%	28.4%
10 - 20	12	8	9	29
	38.7%	29.6%	39.1%	35.8%
> 20	7	7	6	20
	22.6%	25.9%	26.1%	24.7%

Foreman experience by type of construction is shown in Table 6.6. The experience of foremen is classified into 3 categories; Up to 2 years, 2 to 6 years, and more than 6 years with the less experienced foremen (up to 2 years) shown to be equally distributed among the four types of building. Thirty nine percent of the industrial building foremen indicated that there was a tendency for foremen to prefer working on this type of building work.

Table 6.6 Foremen's Experience by Type of Building.

Type of Building	Number and Percentage			
Up to 2 years	**Bricklaying Foremen**	**Carpentry Foremen**	**Steelfixing Foremen**	**Total Foremen**
Housing	7	7	7	21 22.6%
Public Utility	7	6	6	19 20.4%
Industrial	12	10	14	36 38.7%
Commercial	10	5	2	17 18.3%
Total	36 38.7%	28 30.1%	29 31.2%	93 100%
2 - 6 years				
Housing	9	10	7	26 28.9%
Public Utility	8	6	8	22 24.4%
Industrial	3	2	3	8 8.9%
Commercial	9	13	12	34 37.8%
Total	29 32.2%	31 34.4%	30 33.3%	90 100%
More than 6 years				
Housing	8	4	2	14 26.4%
Public Utility	4	6	3	13 24.5%
Industrial	0	1	1	2 3.8%
Commercial	9	6	9	24 45.3%
Total	21 39.6%	17 32.1%	15 28.3%	53 100%

6.2.3 Training and Education

Many of the construction foremen surveyed were not formally trained, either as tradesmen, or foremen. Only 21% attended formal trades schools, 11% had completed apprenticeship programmes organised by contractors and only 1% had been trained in government workshops. The rest had not received any training at all (see Table 6.6). Carpentry foremen appeared to have been largely trained on-site and formed the largest group in most contractors' financed apprenticeship programmes. Perhaps this may explain why carpentry foremen stay longer with their employers than bricklayers? i.e., the latter have little or no allegiance to their employers because they were not trained by them!

Table 6.7 Types of Training / Education Background.

Type of Training	Number and Percentage			
	Bricklaying Foremen	Carpentry Foremen	Steelfixing Foremen	Total* Foremen
Apprenticeship	3	0	6	9
	9.4%	0%	25.0%	10.7%
Formal Trades School	6	7	5	18
	18.8%	25.0%	20.8%	21.4%
On-site Trained	22	21	13	56
	68.8%	75.0%	54.2%	66.7%
Government Workshop	1	0	0	1
	3.1%	0%	0%	1.2%

Note : * The total number of foremen has exceeded because 3 of the foremen had more than one type of training background.

6.3 An Evaluation of On-site Practice

On-site practice was examined through foremen's perceptions of four main groups of factors influencing construction productivity 1). Method of construction, 2). Site management, 3). Working environment, and 4). Level of remuneration provided by employers. Other issues observed, and related to on-site practices were: span of control (SOC), management control, and site management characteristics.

6.3.1 Method of Construction, Site Management, Working Environment, and Remuneration

Tables 6.8 and 6.9 summarise the methods of construction employed and level of site management on the high-rise projects surveyed. About 52% of the foremen considered both the construction method and level of site management employed on their sites as being 'good' to 'very good' with the remainder rating them only 'fair' to 'poor'. There are also obvious losses in production time due to management related problems, for example, have the foremen become so accustomed to certain problems that their judgements become impaired? If a foreman has been on a site with severe managerial problems, it is possible that when moved into another site with comparatively better (but still poor) management style, the new site may be rated as being excellent. This inherent subjectivity is one of the deficiencies of many opinion surveys (see Chapnis, 1982).

Table 6.8 An Evaluation of Method of Construction.

Evaluation of Method of Construction	Number and Percentage			
	Bricklaying Foremen	Carpentry Foremen	Steelfixing Foremen	Total Foremen
Poor	2	1	0	3
	6.5%	3.7%	0%	3.7%
Fair	15	12	9	36
	48.4%	44.4%	39.1%	44.4%
Good	14	13	8	35
	45.2%	48.1%	34.8%	43.2%
Very good	0	1	6	7
	0%	3.7%	26.1%	8.7%

Table 6.9. An Evaluation of Site Management

Site Management	Number and Percentage			
	Bricklaying Foremen	Carpentry Foremen	Steelfixing Foremen	Total Foremen
Very poor	1	0	1	2
	3.2%	0%	3.2%	2.4%
Poor	6	4	2	12
	19.4%	14.8%	8.7%	14.8%
Fair	9	11	5	25
	29.0%	40.7%	21.7%	30.9%
Good	15	11	10	36
	48.4%	40.7%	43.5%	44.4%
Very good	0	1	5	6
	0%	3.7%	21.7%	7.4%

Also given that working environment is the joint responsibility of both head office *and* site office management, their combined policies and actions can positively or negatively affect a foreman's enthusiasm to perform. Fifty six percent of the foremen considered their working environment 'good' to 'very good' (see Table 6.10).

Whilst strikes have not been prevalent in the Indonesian construction industry it does not necessarily mean that construction foremen are satisfied with their remuneration (see Wibisono, 1994b). Rather, the general situation in a developing economy like Indonesia is that remuneration are low with workers having little or no leverage to increase their wages through strikes. Table 6.11 presents a summary of remuneration of construction foremen surveyed with over half of the sample considering their remuneration as being either 'poor' and 'fair'.

Table 6.10 An Evaluation of Working Environment.

Working Environment	Number and Percentage			
	Bricklaying Foremen	Carpentry Foremen	Steelfixing Foremen	Total Foremen
Very poor	0	0	1	1
	0%	0%	4.3%	1.2%
Poor	5	1	1	7
	16.1%	3.7%	4.3%	8.6%
Fair	9	8	11	28
	29.0%	29.6%	47.8%	34.6%
Good	15	17	9	41
	48.4%	63.0%	39.1%	50.6%
Very good	2	1	1	4
	6.5%	3.7%	4.3%	4.9%

6.3.2 Span of control (SOC)

Borcherding (1962) found that in the USA the number of craftsmen per foremen varied between 4 and 25. Obviously, SOC is a function of the type of work, the spread of the work, and the amount of *direct* supervision required. Levitt (1979) found significant differences in SOC practices between union and non-union sectors. Union foremen commonly command a crew force of 12 workers against only 4 of the non-union foreman. The Business Roundtable (1982a,b) suggested that the ratio of first level supervisor (foreman) to craftsmen they supervise, should be determined by collective bargaining agreement *rather than by the employer's decision* - based upon efficiency, economy, and safety factors.

In Indonesia, SOC is largely determined by the foremen themselves, based on how many craftsmen they want to execute the work at hand. In some instances management may enforce a ratio depending on experience and company practice. Also the nature of the project determines the SOC and in general, varies between trades.

Table 6.11 An Evaluation of Level of Payment.

Payment for foremen	Number and Percentage			
	Bricklaying Foremen	Carpentry Foremen	Steelfixing Foremen	Total Foremen
Poor	5	3	1	9
	16.1%	11.1%	4.3%	11.1%
Fair	15	12	10	37
	48.4%	44.4%	43.5%	45.7%
Good	11	11	12	34
	35.5%	40.7%	52.2%	42.0%
Very good	0	1	0	1
	0%	3.7%	0%	1.2%

Table 6.12 presents the results of evaluating foremen span of control. In general, the craftsmen to foreman ratio seems high. Almost 60% of cases show the SOC at 1 : 15. Most foremen (63%) would like this ratio improved to manage their groups more effectively. It is however, very difficult to see how this can be improved in an industry with a dire shortage of foremen and, with no training programme aimed at improving the situation.

Table 6.12 An Evaluation of Foremen's Span of Control.

Span of Control Foreman & Craftsmen Ratio	Condition	Number and Percentage Bricklaying Foremen	Carpentry Foremen	Steelfixing Foremen	Total Foremen
1 : 3 to 8	present	5	1	5	11
		16.2%	3.7%	21.7%	13.6%
	ideal	3	2	3	8
		8.7%	7.4%	13.0%	9.9%
1 : 9 to 15	present	3	6	6	15
		9.7%	22.2%	26.1%	18.5%
	ideal	3	4	7	14
		9.7%	14.8%	30.4%	17.3%
1 : more than 1 5	present	23	20	12	55
		74.2%	74.1%	52.2%	67.9%
	ideal	25	21	13	59
		80.6%	77.8%	56.5%	72.8%

6.3.3 Management Control

Foreman perception of senior management on project progress, is presented in Table 6.13 where sixty eight percent surveyed rated their project managers as having sufficient knowledge of the construction process to avoid delay and increase project cost. It appears that carpenters enjoy most attention from management with 64% reporting that they are in suitably managed situation.

Table 6. 13 An Evaluation of Management Control

Management control only when :	Number and Percentage Bricklaying Foremen	Carpentry Foremen	Steelfixing Foremen	Total Foremen
project progresses (1)	6	1	1	8
	19.4%	3.7%	4.3%	9.9%
project delays (2)	2	6	8	16
	6.5%	22.2%	34.8%	19.8%
neither (1) nor (2)	2	0	0	2
	6.5%	0%	0%	2.4%
Both (1) and (2)	21	20	14	55
	67.7%	74.1%	60.9%	67.9%

6.3.4 Site Management Characteristics

These were evaluated under six expressions with foremen asked to rate on a 5-point scale where 1 = strong disagreement to 5 = strong agreement, whether they agree with these expressions or not. An agreement index was established for each of the expressions using the weighted average formula (mean value given by the respondents divided by 5). Table 6.14 presents results of this evaluation.

Generally, foremen rated the site management characteristics with an agreement index of 0.68, so indicating a good deal of agreement amongst foremen to their present site management characteristics. Note that the highest agreement index emanates from carpentry foremen and seems to correspond with the higher degree of attention provided by site management to this category of employees perhaps suggesting a positive correlation between site management attention and foreman characteristics.

Table 6.14 An Evaluation of Direct Superiors' Characteristics by Foremen

Superior's Characteristics	Agreement Indices and Ranking			
	Average Foremen	Bricklaying Foremen	Carpentry Foremen	Steelfixing Foremen
Around when needed	0.69 6th	0.68 6th	0.65 6th	0.77 3rd
Friendly and Approachable	0.80 1st	0.75 5th	0.82 3rd	0.82 1st
Knowledgeable of his/her job	0.79 5th	0.80 2nd	0.82 3rd	0.74 6th
Skilful	0.80 1st	0.79 3rd	0.83 2nd	0.76 4th
Ensure project information	0.80 1st	0.81 1st	0.84 1st	0.75 5th
Listen to and consider suggestions	0.80 1st	0.79 3rd	0.82 3rd	0.78 2nd
Average	0.78	0.77	0.80	0.77

The expression 'availability of site managers when they were needed' was rated lower (but still high in relative terms) by the foremen. It can therefore be inferred that most foremen are satisfied with the frequency of project managers' presence on-site. This is perhaps due to the fact that the projects managers often delegate their tasks and give more responsibility to their sub-ordinates if they had to travel away from sites.

Foremen tended to agree that senior management were 'friendly and approachable' with an agreement index of 0.80. Better agreement indices provided by carpentry and steel fixing than bricklaying foremen can be explained by the corresponding larger percentages of the first two groups of foremen employed directly by main contractors.

There was a strong agreement index of 0.69 for 'knowledge of management' with regard to construction activities. Carpentry also provided a high agreement among other trades indicating that site management pay particular attention to carpentry work because it very often lies on the critical path of construction activities.

The majority of foremen considered site managers 'skilful' in their jobs. On average, foremen provided an agreement index of 0.80 with carpentry foremen providing the highest index of 0.84. This indicates that carpentry foremen appreciate more the project managers' skill than do other trades.

An agreement index of 0.80 was achieved with respect to 'ability of site management for ensuring and distributing information' needed for the job undertaken. An agreement of 0.80 for 'listen to and consider suggestion' provides an indication of the site management to allow foremen to participate in decision making.

Overall, senior management characteristics correspond with the fact that, on average, delays on the 26 project surveyed was only about 5% of planned progress confirming the finding that overall, projects are well managed in Indonesia.

Table 6.15 An Evaluation of Foremen's Awareness of Project Success.

	Number and Percentage			
	Bricklaying Foremen	Carpentry Foremen	Steelfixing Foremen	Total Foremen
Very aware	12	9	8	29
	38.7%	33.3%	34.8%	35.8%
Aware	18	16	13	47
	58.1%	59.3%	56.5%	58.0%
Very good	1	2	2	5
	3.2%	7.4%	8.7%	6.2%

Table 6.15 presents the results of evaluation regarding foremen awareness to the success of their projects where despite some 36% of respondents considering this the sole responsibility of site management, 64% still rated their projects as nevertheless being successful.

Table 6.16. An Evaluation of Foremen's Stress.

Level of stress	Number and Percentage			
	Bricklaying Foremen	Carpentry Foremen	Steelfixing Foremen	Total Foremen
Very stress	1	0	0	1
	3.2%	0%	0%	1.2%
Stress	3	3	0	6
	9.7%	11.1%	0%	7.4%
Just OK	27	24	23	74
	87.1%	88.9%	100%	91.4%

Table 6.17 An Evaluation of Level of Co-ordination Amongst Foremen.

Level of Co-ordination	Number and Percentage			
	Bricklaying Foremen	Carpentry Foremen	Steelfixing Foremen	Total Foremen
Very Good	1	1	2	4
	3.2%	3.7%	8.7%	4.9%
Good	19	16	19	54
	61.3%	59.3%	82.6%	66.7%
Fair	9	10	2	21
	29.0%	37.0%	8.7%	25.9%
Poor	2	0	0	2
	6.5%	0%	0%	2.5%

The majority of Indonesian foremen seemed to be largely free from physiological burdens as indicated by their response regarding general feeling which 90% reported as satisfactory.

To evaluate the 'level of co-ordination amongst foremen', respondents were asked for a self-assessment rating from 5 (very good) to 1 (very poor). The results presented in Table 6.17 tend towards the majority providing a positive response 'good' (66%) and 'very good' (5%), especially for steel fixing foremen indicating 90% of the responses at this level.

Given such good co-ordination amongst the foremen, it was interesting to investigate whether this co-ordination would influence craftsmen's productivity. The responses presented in Table 6.18 indicate 41% and 22% of respondents respectively considered that foremen co-ordination and effort could 'influence' and 'highly influence' craftsmen's productivity. In contrast, 42% of bricklaying foremen believed that foremen co-ordination and effort had no effect at all upon craftsmen's productivity.

Table 6.18 An Evaluation of the Influence of Foremen Co-ordination Effort on Productivity.

	Numbers and Percentages			
Influence of foremen co-ordination	**Bricklaying Foremen**	**Carpentry Foremen**	**Steelfixing Foremen**	**Total Foremen**
Highly influence	6	8	4	18
	19.4%	29.6%	17.4%	22.2%
Influence	12	12	9	33
	18.7%	44.4%	39.1%	40.7%
Just little influence	0	1	5	6
	0%	3.7%	21.7%	7.4%
No influence at all	13	6	5	24
	41.9%	22.2%	21.7%	29.6%

Table 6.19 Efforts Made by Foremen to Ensure Project's Progress.

Efforts	Numbers and Percentages			
	Bricklaying Foremen	Carpentry Foremen	Steelfixing Foremen	Total Foremen
Advice best method of	17	10	14	41
construction.	44.7%	34.5%	53.8%	44.1%
Adopted or devise	7	6	2	15
better method.	18.4%	20.7%	7.7%	16.1%
Others	14	13	10	37
	36.8%	44.8%	38.5%	39.8%

Finally in order to try to recognise what effort best contributed to project progress, foremen were asked to provide suggestions to senior management. Table 6.19 summarises the results confirming that on average, foremen slightly preferred 'advise as to best method of construction'. While 44% preferred this approach, some 40% indicated 'other methods' including 'improved communication', 'improved level of wages'. Only 16% selected 'adopted and devised better methods'.

6.4 Time Utilisation

Foreman time utilisation in various activities was identified by simple questioning: "How much time do you spend on the following activities in a normal working week": (1) Controlling work pace and quality; (2) giving instructions; (3) reading blueprints; (4) planning work; (5) working as a craftsman (6) completing records; (6) fetching and distributing material; (8) participating in meetings; (9) talking on the telephone; (10) travelling away from site; (11) other activities?'

6.4.1 Time Utilisation by Indonesian Construction Foremen

Table 6.20 shows the percentages from the three types of foremen on the 27 construction sites surveyed, where on average, Indonesian foremen work 56 hours a week within four predominant activities namely:

1. Controlling work pace and quality; (44%) of their time on which bricklaying, carpentry, and steel fixing foremen spent 53% , 40%, 39% respectively.
2. Working as a craftsman but maintaining a supervisory role (8%); for which bricklaying, carpentry, and steel fixing foremen were 11%, 16%, and 25% respectively.
3. Giving instructions (12%) for which bricklaying, carpentry, and steel fixing were 11% , 11%, and 15% respectively.
4. Fetching and distributing materials (6%) for which bricklaying, carpentry, and steel fixing were 5.1% , 9.9%, and 4.9% respectively.

To test the degree of agreement in the way foremen in the 3 trades spend their time (i.e. whether or not they spend their time in the same pattern), a concordance analysis (see Skitmore and Marsden, 1988) was conducted on the 3 different rankings provided. The results presented in Table 6.21 indicate 'Controlling work pace and quality', 'working as craftsmen', 'giving instruction', and 'fetching and distributing materials' dominate with strong agreement of the rank order amongst the three trades foremen as confirmed by a coefficient of concordance (W) of 0.94 and significance: 0.0016.

Table 6.20 Time Utilisation by Foremen in Indonesia.

Activity	Bricklaying foremen			Carpentry foremen			Steelfixing foremen			Average foreman		
	Hour	%	Rank	Hour	%	Rank	Hour	%	Rank	Hour	%	Rank
Control work pace & quality	28.23	52.3	1	23.41	39.9	1	21.61	38.7	1	24.7	43.5	1
Give instruction	6.07	11.2	2	6.52	11.1	3	8.22	14.7	3	6.94	12.4	3
Read blueprints	2.01	3.7	5	4.12	7.0	5	2.37	4.2	6	2.95	5.0	5
Plan work	1.58	2.9	7	2.95	5.0	6	2.95	5.3	4	2.49	4.4	6
Working as a craftsman	5.59	10.4	3	10.22	17.4	2	13.86	24.9	2	9.89	17.6	2
Complete records	1.78	3.3	8	1.49	2.5	8	0.99	1.8	8	1.42	2.5	8
Fetch and distribute material	2.78	5.2	4	5.82	9.9	4	2.73	4.9	5	3.78	6.7	4
Participate in meeting	1.86	3.4	6	0.73	1.2	10	0.96	1.7	9	1.18	2.1	9
Talk in telephone	0.07	0.1	11	0.13	0.2	11	0.05	0.1	11	0.08	0.1	11
Travel away	2.68	0.5	9	2.37	4.0	7	1.33	2.4	7	2.13	3.8	7
Other activities	1.33	2.5	10	0.91	1.6	9	0.70	1.3	10	0.98	1.7	10
Total hours spent weekly	53.98			58.67			55.77			56.14		

Table 6. 21 Overall Ranking of Indonesian Foremen's Time Utilisation.

Variable	Mean rank	Rank
Control work pace and quality;	1.00	1
Give instruction;	2.67	3
Read blueprints;	5.33	5
Plan work	5.67	6
Working as a craftsman	2.33	2
Complete records;	8.00	8
Fetch and distribute material;	4.33	4
Participate in meeting;	8.33	9
Talk in telephone;	11.00	11
Travel away from site;	7.67	7
Other activities control work.	9.67	10

Cases	W	chi-square	D.F.	Significance
3	.9414	28.2424	10	.0017

The next test observed whether the proportion of time spent on various activities were in the same pattern, tested by one-way analysis of variance (ANOVA) on the four highest ranking variables reinforced by the Levene test for homogeneity. Results were as follows:

(1) *Monitoring and inspecting the pace and quality of work* - There are no significant differences between the amount of time spent on this item by bricklaying, carpentry and steel fixing foremen (sig. F = 0.3123). The Levene test shows a reasonable acceptance requirement of homogeneity of the variance examination as indicated by two tailed significant value of 0.629 > 0.05 (see Norusis, 1993). Bonferoni analysis at the 0.05 significance level for multiple rank test provided no subgroups for the three trades foremen.

(2) *Working as a craftsman* - There were significant differences between the amount of time spent on this item by bricklaying, carpentry and steel fixing foremen (sig. F = 0.0345). The Levene test shows a reasonable acceptance for requirement of homogeneity of the variance examination as indicated by a two-tailed significance value of 0.088. Furthermore, Bonferoni analysis at the 0.05 significance level for a multiple rank test provided two subsets for the three trades foremen, with bricklaying and carpentry foremen in one subset, and carpentry and steel fixing foremen in another. In this case, steel fixing foremen spend more than twice the time working as craftsmen than do bricklaying foremen.

(3) *Giving instructions* - There were no significant differences between the amount of time spent on this item by bricklaying, carpentry and steel fixing foremen (sig. F = 0.6101). The Levene test shows a reasonable acceptance requirement of homogeneity of the variance examination as indicated by a two-tailed significant value of 0.691. Furthermore, Bonferoni analysis at 0.05 significance level for multiple rank test provided no subgroups for the three trades foremen. The result indicates that steel fixing foremen seem to spend more time 'giving instructions' than the other trades.

(4) *Fetching and distributing material* - There were no significant differences between the amount of time spent on this item by bricklaying, carpentry and steel fixing foremen (sig. F = 0.3354). The Levene test showed a reasonable acceptance requirement of homogeneity of the variance examination as indicated by a two-tailed significant value of 0.051. Bonferoni analysis at the 0.05 significance level for multiple rank test provided no subgroups for the three trades foremen. The results of ANOVA show that generally there are no significant differences in time utilisation by the three subsets of Indonesian foremen.

A further comparative analysis was carried out after clustering foremen activities into the following three categories:

1. Activities related to *planning* and co-ordinating: planning work, reading reports and blueprints, attending meeting.
2. *Supervisory* activities: giving instructions, monitoring and inspecting the pace and quality of work.
3. *Other* activities: writing reports, collecting and distributing materials, holding telephone conversations, manual work, travelling away from site.

Results indicate that Indonesian foremen spend more than half of their time supervising; especially bricklaying foremen who supervise about 60% of their time. The 'other' category came second with carpentry and steel fixing foremen spending more than 35% of their time in this category. It was observed that carpentry and steel fixing foremen work more as craftsmen than bricklaying foremen. The results clearly indicate that Indonesian foremen spend less time on planning the work (see Figure 6.1).

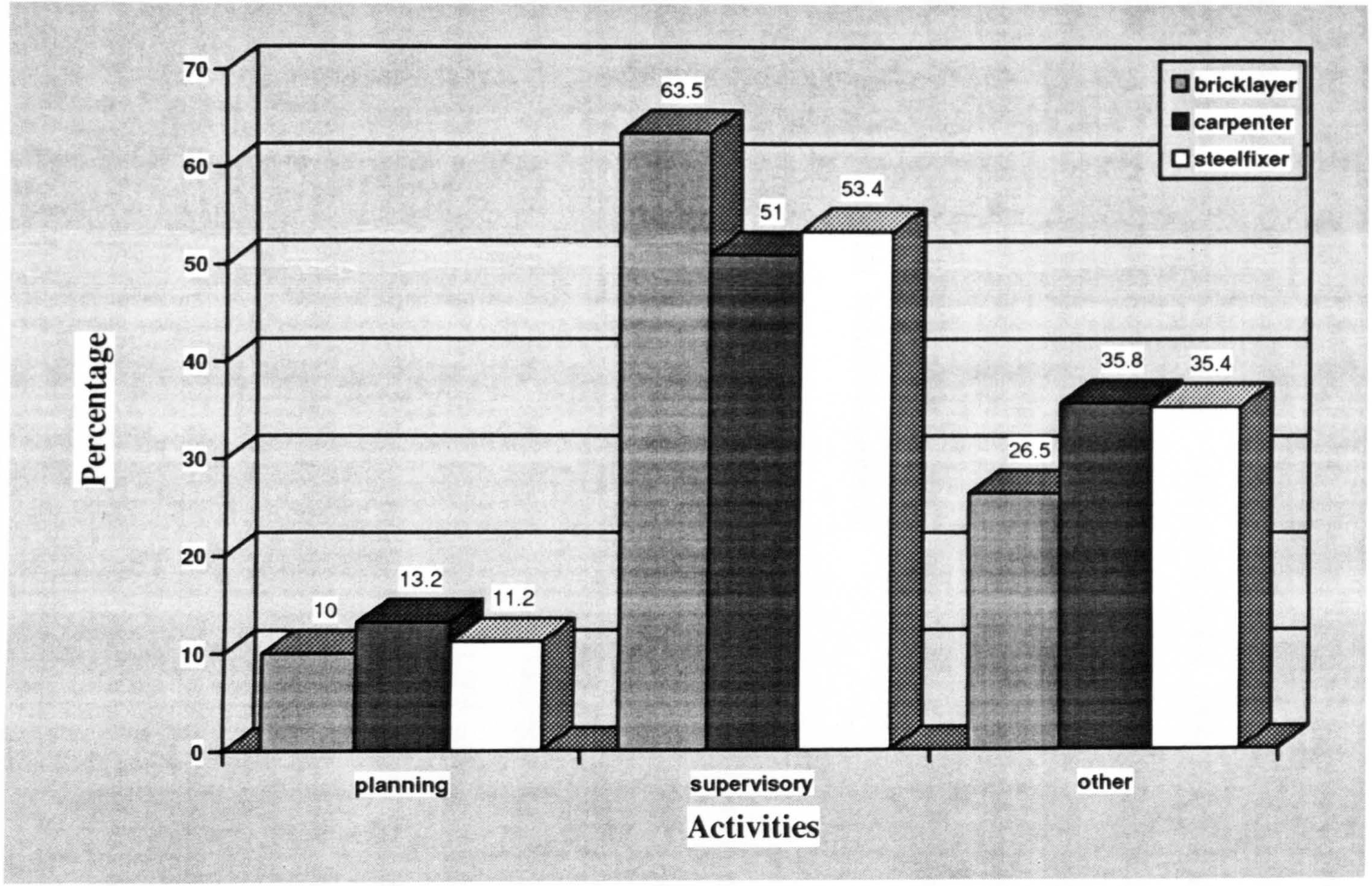

Figure 6.1 How Indonesian Foremen Spend their Time by Type of Activity (in %).

6.4.2 Comparison of Time Utilisation with United States and Israel.

Two similarly patterned studies on construction foremen activities by Laufer and Shohet (1991a,b) provided the basis for comparing these results with Indonesia. Table 6.22 compares the results from the three studies. Controlling work pace and quality is the predominant activity of foremen in the three countries which is hardly surprising, but it is worth noting the percentages viz.; 18% in the USA, 34% in Israel and 44% in Indonesia. The lower percentages in the USA and Israel may be an indication of more highly skilled craftsmen and able to make independent judgements. This reasoning can be linked with the 2nd rated item of 'working as a craftsman'. Indonesian foremen tend to work alongside their crews being similarly skilled. In United States and Israel foremen seldom work as craftsmen (ranked 6th in both countries).

Unfortunately, since raw data for the USA and Israel studies were not available, rigorous examination of the differences between the three countries cannot be made. Nevertheless, using the Spearman rank correlation test between the ranking of time utilisation of foremen in USA, Israel, and Indonesia, results indicates significant similarity in time utilisation across activities between Indonesia and USA with a correlation coefficient (Rs) of 0.80. Correlation between Israel and Indonesian foremen was low (Rs = 0.52) only significant at the 0.1 level, suggesting a difference between the countries' foremen activities.

A second comparative analysis was carried out after clustering the activities into the three categories: planning, supervisory, and other (see Figure 6.2). Indonesian foremen tended to spend more time supervising (56%) than in USA (35%); but comparable to Israel (55%). Indonesian foremen utilised only 11% of their time in planning compared to Israel's (26%) and 36% for the USA. The 'other' category, Indonesian foremen spend 32.2% compared to their counterparts in Israel and USA at 18% and 28% respectively.

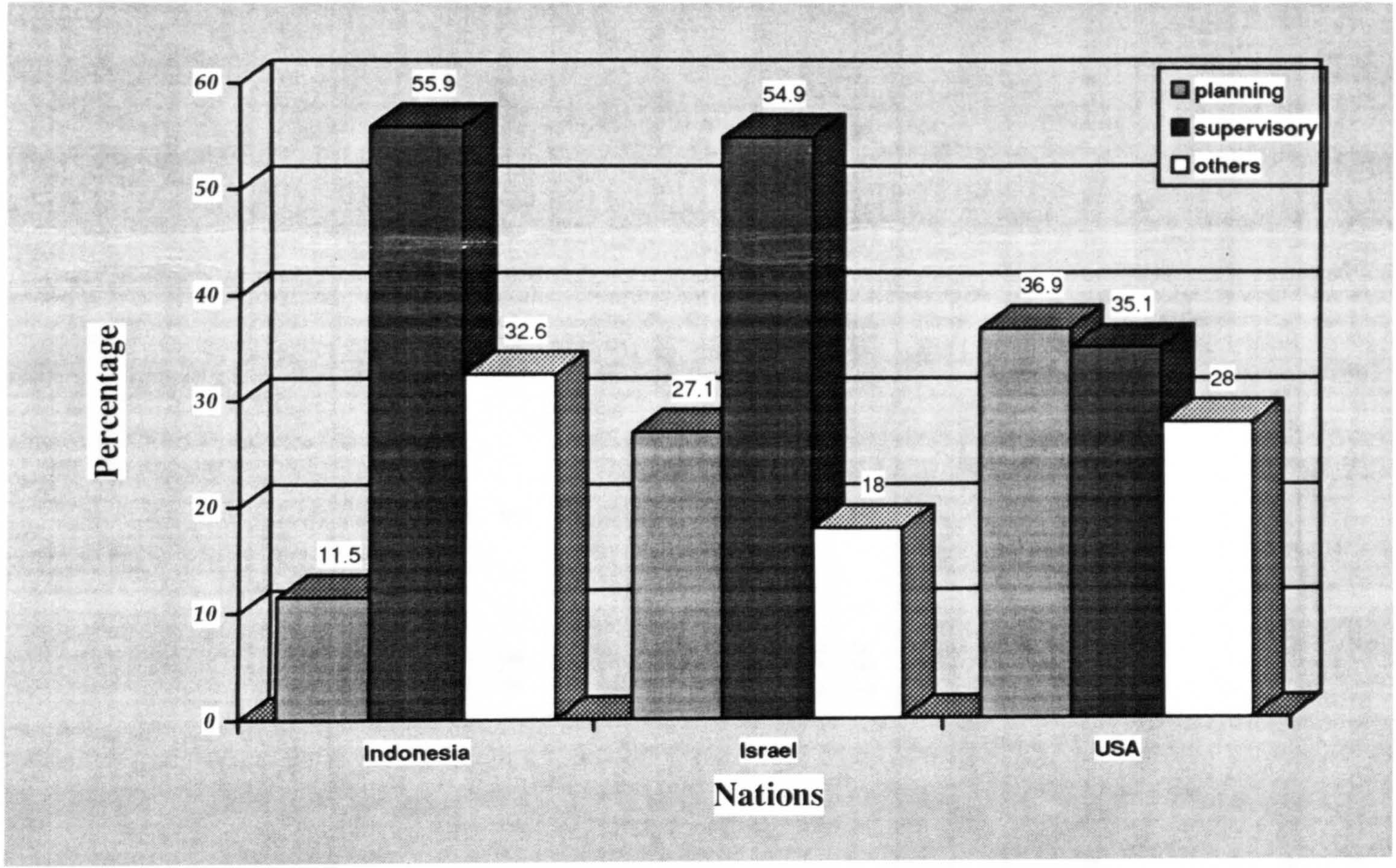

Figure 6.2 Foremen's Time Utilisation in Indonesia, Israel, and USA by Type of Activity (in %)

These differences may in part be attributable to the on-site planning where the uncertain environment require more reaction. According to Laufer (1988), the greater the uncertainty, the more difficult planning becomes, and with it grows the tendency to "control" rather than plan. Secondly, Indonesian foremen, as those in Israel, are responsible for more than one trade group, and hence have a heavier workload to undertake alongside the execution of tasks. Generally, foremen give preference to routine work rather than planning.

Table 6.22 Foreman's Time Utilisation in Texas, Israel, and Indonesia.

Activity	Texas		Israel		Indonesia	
	%	Rank	%	Rank	%	Rank
Control work pace & quality;	18.0	1	33.7	1	43.5	1
Give instruction;	17.1	2	21.2	2	12.4	3
Read blueprints;	16.8	3	9.8	3	5.0	5
Plan work	14.7	4	8.9	4	4.4	6
Work as a craftsman	10.6	5	3.1	9	17.6	2
Complete records;	6.0	6	4.5	6	2.5	8
Fetch and distribute material;	5.9	7	4.0	7	6.7	4
Participate in meeting;	5.5	8	8.4	5	2.1	9
Talk in telephone;	3.9	9	3.8	8	0.1	11
Travel away	0.9	10	2.6	10	3.8	7
Other activities	0.7	11	0.0	11	1.7	10

6.5 Foreman Perception of Productivity Problems

A foreman delay survey questionnaire patterned after NEDO (1989) was employed to investigate productivity problems on construction sites in Indonesia. The eleven productivity problems following Sebastian & Borcherding (1979) and Oglesby, et.al. (1989) devised in Chapter 6 were also presented to the 81 foremen surveyed, to record time lost over a typical 40 hour week. The aim being to ascertain whether foremen and craftsmen agreed on Indonesian construction productivity problems.

Table 6.23 presents the ranking of the eleven productivity problems according to three trades foremen' opinions - ranked in order of severity. To test for agreement amongst the three groups of tradesmen, a concordance analysis was conducted. Overall, the four highest ranking productivity problems in Indonesia being: rework, lack of materials, lack of tools, and interference. A concordance test demonstrated that overall there is a significant acceptable agreement with coefficient of concordance (W) of 0.65 (see Table 6.24).

Table 6.23 Time Lost Due to On-site Productivity Problems.

On-site Productivity Problems	Time lost (in hours) due to productivity problems in a typical week according to							
	Bricklaying Foremen		Carpentry Foremen		Steelfixing Foremen		Average Foreman	
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
Lack of material	1.51	3	1.43	2	3.05	1	2.00	2
Lack of tools	1.23	5	1.27	3	1.30	4	1.27	5
Equipment breakdown	0.85	7	1.08	4	0.85	5	0.93	6
Rework	1.87	2	2.87	1	1.82	3	2.19	1
Changing of workers	0.55	8	0.73	5	0.05	10	0.44	9
Interference	1.47	4	0.56	7	2.16	2	1.40	3
Absenteeism	2.84	1	0.62	6	0.44	8	1.30	4
Supervision delays	0.20	9	0.46	8	0.72	6	0.46	8
Changing of foremen	0.06	10	0.00	11	0.04	11	0.03	11
Too much work	1.03	6	0.12	10	0.33	9	0.49	7
Over crowded	0.03	11	0.37	9	0.58	7	0.33	10

Table 6.24 Overall Ranking of Productivity Problems According to Foremen.

Productivity Problems	Mean rank	Rank order
Lack of material	2.00	1
Lack of tools	4.00	3
Equipment breakdown	5.33	6
Rework	2.00	1
Changing of workers	7.67	7
Interference	4.33	4
Absenteeism	5.00	5
Supervision delays	7.67	7
Changing of foremen	10.67	11
Too much work	8.33	9
Over crowded	9.00	10

cases	W	chi-square	DF	Significance
3	0.7455	22.3636	10	0.0134

To test the agreement of severity of the productivity problems between the three craftsmen and their respective trades foremen, again, Kendall concordance analysis was carried out (see Table 6.25). Results indicate that there was significant agreement amongst the six groups of rankings provided by the foremen and craftsmen with a coefficient (W) of 0.65.

Clearly both groups are in agreement concerning the 4 major construction productivity problems identified: lack of material, rework, absenteeism, and interference.

6.5.1 Lack of Materials

Overall, this ranked the most important influence on craftsman productivity (by both foremen and craftsmen) but was considered only second by foremen themselves. Understandably, Indonesian foremen were so concerned with 'fetching and distributing material' ranking it the fourth in time utilisation. The mean of unproductive time caused by materials unavailability for steel fixers was 3.05 hours, bricklayers 1.51 hours, and carpenters 1.43 hours. In order to determine the causes the craftsmen were again requested to rank a list of the causes in rank order. Results of the analysis are presented in Table 6.26 indicating that 'On-site transportation difficulty' was cited as 1st, 'Inadequate material storage' 2nd, 'Inadequate planning' 3rd, and 'Excessive paper work for requests' 4th.

Table 6.25 Overall Ranking of Productivity Problems According to Craftsmen and Foremen.

Productivity Problems	**Mean rank**	**Rank order**
Lack of material	1.83	1
Lack of tools	4.75	5
Equipment breakdown	6.00	6
Rework	2.33	2
Changing of workers	7.75	7
Interference	3.83	3
Absenteeism	4.00	4
Supervision delays	8.00	8
Changing of foremen	10.75	11
Too much work	8.08	9
Over crowded	8.86	10

cases	W	chi-square	DF	Significance
6	0.7479	44.8710	10	0.0000

On-site transportation difficulty was cited as the major problem. This is not surprising since most of the high rise buildings were being constructed on congested urban sites with difficulties in manoeuvring and getting materials to point of use. Improper allocation of materials or lack of materials storage were also typical problems in such urban high-rise construction. Of the 26 companies studied, inadequate materials was evident leading in many instances to delays of supplies by vendors and on-site distribution i.e., from site storage to point of use.

Table 6.26 Causes of Material Unavailability.

Causes of Material Unavailability	Bricklaying Foremen		Carpentry Foremen		Steelfixing Foremen		Foremen	
	Mean Rank	Rank Order	Mean Rank	Rank Order	Mean Rank	Rank Order	Mean Rank	Rank Order
1. On-site transportation	2.22	2	2.28	2	1.73	1	2.09	1
2. Excessive paper works	3.20	4	3.09	4	2.91	3	3.07	4
3. Improper material storage	2.08	1	2.20	1	2.34	2	2.20	2
4. Inadequate planning	2.50	3	2.43	3	3.02	4	2.63	3
Cases	25		27		22		74	
Significant level	0.0108		0.0460		0.0286		0.000	

Table 6.27 Causes of Reworks.

Causes of Rework	Bricklaying Foremen		Carpentry Foremen		Steelfixing Foremen		Foremen	
	Mean Rank	Rank Order	Mean Rank	Rank Order	Mean Rank	Rank Order	Mean Rank	Rank Order
1. Poor instruction	3.00	4	2.56	3	2.32	2	2.64	2
2. Design changes	1.22	1	1.30	1	1.32	1	1.28	1
3. Poor workmanship	2.91	3	3.72	4	3.16	3	3.27	4
4. Complex specification	2.87	2	2.43	2	3.20	4	2.81	3
Cases	27		27		22		76	
Significant level	0.000		0.000		0.000		0.000	

6.5.2 Rework

Rework ranked the second most important problem in Indonesia by both foremen and craftsmen, but considered of most importance by foremen themselves. Carpenters spend more time than other trades on rework. Overall, the causes related to 'design changes', 'poor instruction', 'complexity of the design specification' and 'poor workmanship' ranking 1st, 2nd, 3rd, and 4th respectively. Naturally, 'Design changes' inevitably requires a very good agreement amongst the three foremen groups (see Table 6.27).

6.5.3 Work Interferences

Interference between gangs and workers is primarily related to mismanagement and work sequencing and ranked the third productivity problem by both Indonesian foremen and craftsmen with steel fixers suffering most since they are very dependent on other trades; e.g. they are idle if carpenters have not completed formwork.

Interference can also be caused by unbalanced gang sizes. Investigation towards how foremen considered gang size (craftsman over the his helpers) to eliminate interference was not carried out. However, a survey of gang size (craftsmen's view) has been previously reported, indicating that the two variables were significantly correlated (see Chapter 5).

6.5.4 Absenteeism

Indonesian foremen ranked absenteeism the fourth most important productivity problem. Being well recognised, contractors try to solve this by providing accommodation for workers on site to monitor them. In fact, about 65% of the workers surveyed were accommodated on the sites. Nevertheless, it remains a considerable productivity problem with the bricklaying group most notorious (see Table 6.25). Reasons (especially for bricklayers) likely relate to a background of farming; they would rather be on their farms during planting season than on construction sites.

6.6 Summary

Most Indonesian foremen employed in high-rise construction are aged between 30 to 50 years, the majority (66%) have no structured construction/management training with only 21% trained in trades school, and only 11% completing apprenticeships. The foremen surveyed were more experienced in commercial buildings and housing, rather than public utility and industrial buildings; and are likely to have a larger span of control than their American counterparts, with current foreman to craftsmen ratio of 1: 15.

As in other developing countries, Indonesian foremen spend most of their time supervising, especially, in 'supervising work pace and quality'. In contrast to foremen in developed countries, Indonesian foremen spend more time 'working as craftsmen' whilst supervising, fetching and distributing materials.

Finally, this chapter has presented a detailed overview of the work of foremen in Indonesia concerning management functions and their associated effects on craftsmen' productivity. The most striking feature being the role of supervisor - cum - inspector. Indonesian foremen would improve their efficiency by improving their control through pre-project planning; sensible planning during project execution may also lead to improved on-site productivity.

CHAPTER 7

CHAPTER 7

PRODUCTIVITY PROBLEMS IN INDONESIA - A SURVEY OF PROJECT MANAGERS

7.1 Introduction

Like other developing countries such as Nigeria (see Okpala & Aniekwu, 1988; Mansfield et.al, 1994) and Malaysia (see Yong, 1987), Indonesian construction also suffer from delays and cost overruns which are indicators of productivity problems. Improving construction productivity would contribute to eliminating such time/cost overrun problems. Productivity problems have been identified through craftsmen questionnaire survey (Chapter 5) and foremen survey (Chapter 6). In an attempt to understand these problems, a further investigation of project managers' perception of productivity problems in Indonesia was carried out. If there is a common understanding of productivity problems it should be easy to devise a common solution.

The intentions of this chapter may therefore be stated as:

(1) to identify predominant factors influencing construction productivity in terms of their importance, frequency, and severity on current projects;

(2) to analyse the relationship of importance to frequency of these factors;

(3) to compare factors influencing productivity ranked by PMs with their respective foremen and craftsmen and;

(4) to evaluate the influence of productivity factors on overall severity of productivity problems.

7.2 Results and Discussion

7.2.1 Identification of Productivity Problems

Table 7.1 presents importance, frequency, and severity of productivity problems identified by project managers. The importance of the factors was ranked by PMs based on their cumulative working experiences (4 = 'very importance' to 1 = 'not importance'), the frequency of occurrence (3 = 'high' to 1 = 'low') of productivity problems was gauged on their 'current project' being surveyed. The severity of the problem was the product of importance and frequency measures.

Using relative indices formula (see Olomolaiye et.al., 1987), the relative importance, frequency and severity indices were obtained. Results indicated that project managers realised the importance of factors, such as lack of material (0.93), rework (0.86), and interference (0.84) and ranked them 1st, 2nd, and 3rd respectively. The most frequent productivity problems were identified as absenteeism (0.67), reworks (0.65), and interference (0.64) ranked as 1st, 2nd, and 3rd respectively. This indicates that project manager considered absenteeism - although only ranked 4th in terms of importance - the most common and frequently occurring of the productivity problems. The absenteeism of craftsmen could be avoided by proper sequencing of the works in order to minimise the number of return visits for trades.

The importance ranking of productivity problems does not appear to correspond to their frequency of occurrences (see Table 7.1) A severity index was generated by multiplying the importance and frequency. The ranking of the severity was used to gauge the causes of low craftsmen's productivity and were ranked 1st for reworks (0.57), and 2nd for both interference (0.55), and absenteeism (0.55). The mean importance, frequency, and severity indices of the productivity problems for high-rise construction in this exploratory study are 0.78, 0.56, and 0.45 respectively (0 = low and 1 = high). These severity indices may serve as a benchmark for future comparison.

Table 7.1 Identification of Productivity Problems by Project Managers.

Factors Influencing	Importance		Frequency		Severity	
Productivity	Index	Ranking	Index	Ranking	Index	Ranking
Lack of material	0.93	1	0.58	6	0.52	4
Lack of tools	0.74	7	0.48	9	0.36	10
Equipment breakdown	0.78	5	0.49	8	0.40	7
Repeat work.	0.86	2	0.65	2	0.57	1
Changing craftsmen.	0.77	6	0.62	4	0.48	5
Interference.	0.84	3	0.64	3	0.55	2
Absenteeism.	0.80	4	0.67	1	0.55	2
Supervision delay.	0.74	7	0.48	10	0.37	9
Overcrowding.	0.71	10	0.54	7	0.39	8
Changing foreman	0.72	9	0.44	11	0.32	11
Working overtime	0.71	10	0.61	5	0.44	6
Average =	0.78		0.56		0.45	

7.2.2 Relationship of the Productivity Factors

Table 7.2 exhibits the correlation coefficients of the factors, in terms of importance (I), and severity (S) respectively. There are two essential categories of the relationship of the factors based on combination of significant correlation between the importance and severity. Notably, all the factors which were significantly correlated have a positive sign indicating that increase importance / severity in one problem may increase also importance / severity of another problem. The categories include:

1. Significance in two correlation measures (importance, and severity).
2. Significance in two correlation matrices (either importance or severity).

The discussion is focused on the first category because it is considered that in spite of the PMs being aware of the importance of the factors, productivity problems were quite severe on site. Factors correlated in this category are: 'lack of material' and 'interference'; 'lack of material' and 'absenteeism'; 'equipment breakdown' and 'absenteeism'; 'rework' and 'working overtime'; 'interference' and 'absenteeism'; and 'supervision delay' and 'overcrowding'.

'Lack of materials' was found to be significantly correlated with 'gang interference' according to both importance and severity indicating that increase in gang interferences is a direct consequence of delays of supplying materials on job-site by management. Delays caused by materials unavailability could take place due to disorder by site management or supplier. This generally results in additional working time when the material does arrive. Such delays destabilize work sequence within activities and between different trades. For instance, delay caused by carpenters in setting doors and windows frame because of the unavailability of material can prevent bricklayers laying bricks to the walls. Furthermore, the interference of work crews could also effect the availability of materials on job site because the capacity of site transportation of material can not cope with accumulation of delay works.

Table 7.2 Correlation Matrix of Importance (I) and Severity (S) of Factors Influencing Productivity.

Productivity Problems		P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
P1 Lack of material	I	1.00										
	S	1.00										
P2 Lack of tools	I	0.39*	1.00									
	S	0.16	1.00									
P3 Equipment breakdown	I	0.10	0.02	1.00								
	S	0.27	0.08	1.00								
P4 Rework.	I	0.14	-0.01	0.21	1.00							
	S	0.31	0.31	0.02	1.00							
P5 Changing craftsmen.	I	0.37*	0.24	0.05	-.018	1.00						
	S	0.22	0.12	0.40*	0.26	1.00						
P6 Interference.	I	0.45**	0.14	0.19	0.12	0.07	1.00					
	S	0.51**	-0.06	0.46**	0.31	0.47**	1.00					
P7 Absenteeism.	I	0.45**	0.18	0.37*	0.24	0.11	0.64**	1.00				
	S	0.37*	-0.03	0.43*	0.25	0.29	0.60**	1.00				
P8 Supervision delay.	I	0.21	0.20	0.43*	0.28	0.09	0.14	0.25	1.00			
	S	0.12	0.37*	0.09	0.20	0.22	-0.04	0.17	1.00			
P9 Overcrowding.	I	0.12	0.25	0.23	0.02	0.03	0.06	0.06	0.65**	1.00		
	S	0.26	0.23	0.00	0.24	0.09	-0.06	0.09	0.43*	1.00		
P10 Changing foreman	I	0.32	0.53**	0.16	-0.15	0.45**	-0.12	0.05	0.26	0.47**	1.00	
	S	-0.02	-0.06	0.18	0.07	0.33	0.14	0.16	0.02	0.19	1.00	
P11 Working overtime	I	0.26	0.06	0.44**	0.52**	0.22	0.17	0.25	0.14	-0.06	-0.05	1.00
	S	0.36*	0.30	0.32	0.45**	0.47**	0.34	0.35*	0.18	0.24	0.19	1.00

Note: * Significance at 0.05 level, and ** at 0.01 level.

'Lack of material' and 'absenteeism' are significantly correlated indicating that materials mismanagement including delay in supplying materials may cause lead to absenteeism. If there is no sufficient material, workers can not carry out their tasks. Sub-contractors may move their workers to other sites.

'Equipment breakdown' and 'absenteeism' are significantly correlated indicating that if equipment is not well maintained, it may lead to difficulties in materials transportation as well as problem in mobilising workers to do their tasks. As a result, workers may move or be moved by subcontractors to other sites. This supports the previous significant correlation between 'lack of material' and 'absenteeism'.

The more 'rework', the more 'working over time', and vice versa. Rework was found to be significantly correlated with working overtime. Indeed, working overtime is often due to rework because of mistakes or unacceptable quality. Conversely, rework can also be caused by excessive overtime by craftsmen becoming exhausted and resulting in poor quality / unacceptable work. Changing crew members was also found to be significantly correlated with working over-time.

'Interference' was significantly correlated with 'absenteeism' in importance and severity. Increase in absenteeism would increase interference of work crews because it leads to unbalance in the production unit leading to target outputs not being met. Not meeting targets may lead to working overtime which in itself may cause more interference as gangs rush to meet new targets.

7.2.3 Comparison of Ranking of Productivity Problems

Problem importance ranking according to Project Managers, Foremen, and craftsmen were analysed using Kendall concordance method. Table 7.3 exhibits problem ranking of the eleven productivity problems for each group of the respondents. Although not in the same order, result of the concordance analysis indicates that there is a good agreement by the three groups. This is shown by the coefficient of concordance (W) of 0.72 (0 = 'no agreement at all' to 1 = 'perfect agreement'). The agreement ranking is shown if the last column of the table. They all agree that the most severe productivity problems are 'lack of material', 'absenteeism', 'worker interference', 'rework' and 'changing craftsmen'. The probability that the agreement among the three groups could be by chance had their rankings been random or independent was 0.017.

This low probability enables us to reject the null hypothesis that the respondents' ranking are unrelated to each other and conclude that there is good consensus among the groups concerning the factors which influence productivity.

Table 7.3 Comparative Productivity Problem Ranking.

Crafts productivity problems	Project Manager questionnaire	Foreman * Questionnaire	Craftsmen** Questionnaire	Kendall Rank (Overall)
Lack of material	4	2	1	1
Lack of tools	10	5	5	7
Equipment breakdown	7	6	6	6
Repeat work.	1	1	8	4
Changing craftsmen.	5	8	4	5
Interference.	2	4	3	3
Absenteeism.	2	3	2	2
Supervision delay.	9	9	9	10
Overcrowding.	8	11	11	11
Changing foreman	11	7	7	8
Working overtime	6	10	10	9

Case	W	Chi-square	D.F.	Significance
3	0.72	21.58	10	0.017

Note: * and ** are from Chapter 5 and 6 respectively.

Table 7.4 exhibits causes of unavailability of materials as identified by PMs. By employing Friedman ranking analysis, results provided significant ranking indicating 'supplier delays 'as 1st, 'inadequate planning' 2nd, and 'improper material storage' 3rd, and so on. Although direct comparison could not be achieved because the number of variables investigated for PMs was 5, whilst the other sub-samples investigated were 4. The data seem to suggest that PMs and operatives (foremen and craftsmen) do not have the same perception on causes of 'material unavailability.

Table 7.4 Comparison of Causes of Material Unavailability

Causes of Material Unavailability	**Project Managers**		**Foremen***		**Craftsmen****	
	Mean Rank	Rank Order	Rank Order	Mean Rank	Rank Order	Mean Rank
On-site transportation	3.34	4	2.09	1	1.92	1
Excessive paper works for request	3.60	5	3.07	4	2.78	3
Improper material storage	3.08	3	2.20	2	2.24	2
Inadequate planning	2.89	2	2.63	3	3.06	4
Supplier delays	2.10	1				
Cases	31		74		169	
Significant level	0.003		0.000		0.000	

Note: * and ** are adopted from Chapters 5 and 6 respectively.

Table 7.5 exhibits a comparison of causes of rework as ranked by PMs, foremen, and craftsmen. Remarkably, PMs, foremen, and craftsmen seemed to agree that reworks were due to 'design changes'. Notably, PMs blamed poor workmanship as 2nd, whilst operatives claimed 'poor instruction' (from managers) as the 2nd cause of rework.

Table 7.5 Comparison of Causes of Reworks.

Causes of Rework	Project Managers		Foremen*		Craftsmen**	
	Mean Rank	Rank Order	Mean Rank	Rank Order	Mean Rank	Rank Order
Poor instruction	2.89	3	2.64	2	2.38	2
Design changes	1.88	1	1.28	1	1.31	1
Poor workmanship	2.33	2	3.27	4	3.02	3
Complex specification	2.91	4	2.81	3	3.29	4
Cases	32		76		209	
Significant level	0.003		0.000		0.000	

Note: * and ** are from Chapters 5 and 6 respectively.

7.2.4 Contribution of Factors to Overall Productivity

The overall productivity problems of the projects were the subjective assessment obtained from their project managers. They were asked to rate how importance the productivity problems in relation to project objective ranging from 4 (very Importance) to 1 (not importance), and how frequent the problem occur on their sites? The product of importance and frequency is then calculated for each project and regarded as the dependent variable of a regression analysis. We might want to know whether one factor is influences overall productivity than others. Two questions may be asked:

1. How important is a factor to overall productivity if it is the only independent variable in a regression equation?
2. How important is a factor when used to evaluate overall productivity in the company of other independent variables in a regression equation?

The first question may be answered by simply looking at the correlation coefficient between overall productivity and independent variables. The larger the absolute value of correlation coefficient (R_S), the stronger the linear association. Table 7.6 shows that three strongly significant correlation ($P \leq 0.01$) of independent variables: 'lack of material', 'rework' and 'worker interference' have similar R_S as being 0.78, 0.78, and 0.74 respectively to overall severity of the productivity problem. Thus, we would conclude that the first two factors are more important contributors to overall productivity than the third variable.

Table 7.6 Correlation of Factors Influencing Productivity to Overall Severity of the Problem.

Productivity Problems	Overall Severity
P1 Lack of material	0.78 **
P2 Lack of tools	-0.11
P3 Equipment breakdown	0.22
P4 Rework.	0.78 **
P5 Changing craftsmen.	0.00
P6 Interference.	0.74 **
P7 Absenteeism.	0.30
P8 Supervision delay.	0.34
P9 Overcrowding.	0.32
P10 Changing foreman	0.10
P11 Working overtime	0.12

Note: * Significance at 0.05 level, and ** at 0.01 level.

The answer to the second question is considerably more complicated. When the independent variables are correlated among themselves, the unique contribution of each is difficult to assess. Any statement about an independent variable is contingent upon the variables in the equation. For example, the regression coefficient (B) for 'lack of material' is 0.77 when it is the solely independent variable in the equation, compared to 0.42 when the other ten variables are in the equation. The first coefficient is about twice the size of the second.

Results from the stepwise regression analysis shown in Table 7.7 indicate that three variables 'lack of material', 'rework', and 'working overtime' were significantly included in the equation. First stepwise yielded equation E1 with rework (S4) contribute 61% to the variability of overall severity of productivity problem. In the second stepwise, lack of materials (S1) was included in the equation with both factors explaining 78% variability. Finally, Working overtime (S11) was included in the equation explaining 81% of variability of the three factors to overall severity of productivity problem.

Table 7.7 Relationship of Factors Influencing Productivity to Overall Productivity Problem.

No	Equation appeared at stepwise regression	R^2
E1	OSPI = 0.30 + 0.70 * S4	0.61
E2	OSPI = 0.13 +0.49 *S1 + 0.45 * S4	0.78
E3	OSPI = 0.20 + 0.50 *S1 + 0.511 * S4 - 0.26 * S11	0.81

Note: OSPI = Overall Severity of Productivity Index, and S = Severity of the Productivity Problem.

Notably, 'worker interference' (S6) was significantly correlated with overall productivity independently, but did not significantly influence the overall productivity when it applied together with other independent variables. In contrast, 'working overtime' (S11) did not significantly correlate with overall severity of productivity independently, but it did significantly influence overall productivity when a stepwise regression analysis was applied.

Remarkably, the influence of 'working overtime' to overall severity of productivity problem was negative indicating that applying working overtime to workers would help reduce the severity of productivity problems. This is in line with the previous finding (see Chapter 5) regarding characteristics of workers in developing countries who expect to supplement their income by working longer time. If they cannot provide longer time for working, they are not be happy.

7.3 Summary

Project managers surveyed considered 'Lack of material' as being the paramount productivity problem, 'absenteeism' the most frequently occurring problems on sites surveyed, and 'rework' the most severe of the productivity problems. The severity of the productivity problems were compared to those identified by foremen and craftsmen using Kendall concordance analysis. Results provided significant concordance of 72% indicating that the PMs, foremen, and craftsmen tend to have similar views of variables influencing productivity on high-rise construction in Indonesia. This confirms the hypothesis stated in Chapter 4 that to improve productivity on construction sites in Indonesia, there must be agreement by the main on-site participants of nature, type, and source of problems. Hence it should be possible to develop a construction productivity audit system as part of a comprehensive effort at improving construction productivity in Indonesia.

CHAPTER 8

CHAPTER 8

A COMPARATIVE STUDY OF CONSTRUCTION PRODUCTIVITY IN SEVEN REGIONS OF INDONESIA

8.1 Introduction

This chapter presents a comparative study of construction productivity problems for seven regions in Indonesia, namely: Jakarta, Yogyakarta, West Java, Central Java, East Java, Western and Eastern Regions of Indonesia. Construction productivity variables compared include: production output, craftsmen's skill, motivation, remuneration, severity of labour productivity problems, level of supervision, foreman motivation and remuneration. Using Yogyakarta as a benchmark, twenty site personnel with experience of working with construction labour in Yogyakarta and, in at least one other region were surveyed using structured questionnaires and supporting interviews, their broad work experiences resulted in seventy eight sets of comparable data.

Economic and population growth in Indonesia have led to increased demand for social housing, building, and infrastructure particularly in regions outside Java. With encouragement by the Government, the regions will hopefully witness economic development. Initially, the industry should be prepared to face some problems particularly when contractors are awarded construction projects in areas where they have no previous experience.

In the past, when contractors were awarded projects in regions where they had not had much experience, they had three options to providing the necessary construction labour:

1. recruit construction workers from other regions, whose qualities and experience of other region are known;
2. sublet the labour element of work to specialist 'labour-only' subcontractors;
3. recruit construction workers from other regions, but only for skills not available locally.

These three alternatives have led to different organisational approaches on sites in different regions, different production rates and different worker motivation patterns. The comparative investigations reported in this chapter would establish productivity indices for seven regions. These indices would be installed in the construction productivity audit system and can be used for awareness of regional deviations.

8.2 The Productivity Variables

Construction productivity variables in this comparative exercise include: production output, percentage productive time, craftsmen motivation, skill and remuneration; levels of foremen supervision, foreman motivation and remuneration, and overall severity of productivity problems. The prime objective of the exercise was to establish productivity indices for the seven regions. The variables are briefly described in Table 8.1 much in line with the established literature in both developing and developed countries (see Borcherding, et. al 1980; Chang & Borcherding, 1985; Maloney & McFillen, 1987a, 1987b, 1988; Olomolaiye, 1988; and Olomolaiye & Ogunlana, 1989b).

Table 8.1 Description of Productivity Variables

Variables	Description
Production output	Quantity of work done over a period of time. i.e. m2/day, m3/day, ton/day. It is often the basis for cost estimating and wage rates (see Olomolaiye & Ogunlana, 1989b).
Time spent working productively	Time spent in productive activities while working. Productive work in bricklaying, for instance, includes: spreading mortar, fetching mortar, fetching brick, cutting brick, laying brick, filling joints, measuring, setting and checking, and raking and pointing (see Olomolaiye, 1988)
Motivation	The desire to work, excel at work, and be productive during work.
Skill level	Ability to combine all necessary productive motions to achieve a standard output. The measurements include dexterity, construction education/ training back ground, experience in construction work, accuracy in carrying out the work, and having initiative to work (see Bowey and Lupton, 1973).
Remuneration	Amount of money (in Rupiah) received by a craftsman in standard working time. Indonesia is a low wage economy. Construction workers take home about £3 per day.
Level of supervision	This is defined as to the extent of which foremen take care of quality of the works. This may includes planning for resources when needed, giving instructions, supervising the quality as well as quantity of works being undertaken. Generally, the better the supervision level, the smaller the amount of necessary rework.
Productivity problems	Problems include local shortage of skilled labour, poor production output, lack of motivation, and insubordination.
Severity of productivity problems	The level of importance of a problem to productivity vis-à-vis its frequency of occurrence.

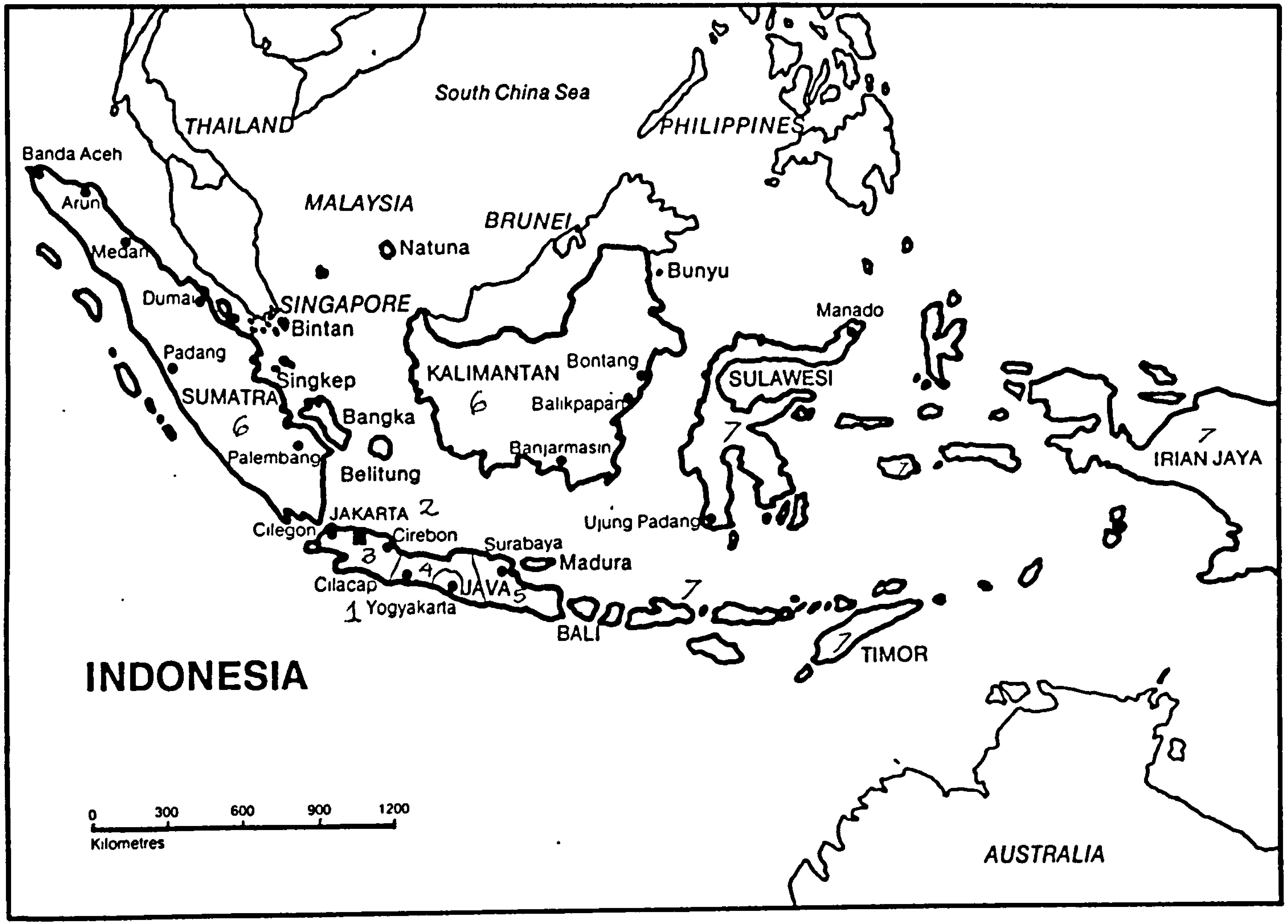

Figure 8.1. The Seven Regions of Indonesia Studied.

8.3 Results and Discussions

Table 8.2 exhibits the productivity indices as well as other statistical details for the seven regions with Yogyakarta as the benchmark. Overall, Jakarta's craftsmen were found to have better skill levels and higher motivation. Production output, working time, and remuneration are also relatively higher than in other regions. Note that all results have absolute significance except for the Western Region of Indonesia, confirming that workers from different regions have different productivity indices.

Table 8.2 Crafts Based Productivity Indices for the Seven Regions of Indonesia.

Bricklayers' Production Output	Index	SD	Min	Max	N	P
Yogyakarta	1.00	0.00	1.00	1.00	20	0.000
Jakarta	1.35	0.19	1.00	1.70	13	0.000
West Java	1.15	0.11	1.00	1.25	8	0.000
Central Java	1.09	0.09	1.00	1.25	16	0.000
East Java	1.20	0.10	1.00	1.30	11	0.000
Western region of Indonesia	0.60	0.28	0.40	0.80	2	0.205
Eastern region of Indonesia	0.68	0.18	0.40	0.85	7	0.000
Carpenters' Production Output						
Yogyakarta	1.00	0.00	1.00	1.00	20	0.000
Jakarta	1.32	0.20	1.00	1.50	13	0.000
West Java	1.14	0.11	1.00	1.25	8	0.000
Central Java	1.10	0.10	1.00	1.30	16	0.000
East Java	1.25	0.20	1.00	1.60	11	0.000
Western region of Indonesia	0.60	0.28	0.40	0.80	2	0.205
Eastern region of Indonesia	0.66	0.20	0.40	0.85	7	0.000
Steelfixers' Production Output						
Yogyakarta	1.00	0.00	1.00	1.00	20	0.000
Jakarta	1.32	0.16	1.00	1.50	13	0.000
West Java	1.16	0.12	1.00	1.30	8	0.000
Central Java	1.07	0.09	1.00	1.30	16	0.000
East Java	1.21	0.13	1.00	1.50	11	0.000
Western region of Indonesia	0.60	0.28	0.40	0.80	2	0.205
Eastern region of Indonesia	0.65	0.17	0.40	0.85	7	0.000

Note: SD = Standard Deviation; N = Valid Number; P = Probability

Table 8.2 (continued)

Craftsmen's Production Output	Index	SD	Min	Max	N	P
Yogyakarta	1.00	0.00	1.00	1.00	20	0.000
Jakarta	1.33	0.16	1.00	1.50	13	0.000
West Java	1.15	0.11	1.00	1.25	8	0.000
Central Java	1.08	0.08	1.00	1.25	16	0.000
East Java	1.21	0.12	1.00	1.40	11	0.000
Western region of Indonesia	0.60	0.28	0.40	0.80	2	0.205
Eastern region of Indonesia	0.66	0.18	0.40	0.85	7	0.000
Time Spent Working						
Yogyakarta	1.00	0.00	1.00	1.00	20	0.000
Jakarta	1.31	0.27	1.00	2.00	13	0.000
West Java	1.21	0.16	1.00	1.50	8	0.000
Central Java	1.03	0.09	0.80	1.20	16	0.000
East Java	1.15	0.09	1.00	1.30	11	0.000
Western region of Indonesia	0.75	0.21	0.60	0.90	2	0.126
Eastern region of Indonesia	0.74	0.18	0.50	1.00	7	0.000
Craftsman's Skill						
Yogyakarta	1.00	0.00	1.00	1.00	20	0.000
Jakarta	1.29	0.20	1.00	1.50	13	0.000
West Java	1.15	0.11	1.00	1.30	8	0.000
Central Java	1.07	0.80	1.00	1.20	16	0.000
East Java	1.20	0.25	1.00	1.75	11	0.000
Western region of Indonesia	0.65	0.21	0.50	0.80	2	0.144
Eastern region of Indonesia	0.69	0.20	0.50	1.00	7	0.000
Craftsman's Motivation						
Yogyakarta	1.00	0.00	1.00	1.00	20	0.000
Jakarta	1.31	0.25	1.00	1.80	13	0.000
West Java	1.24	0.16	1.00	1.50	8	0.000
Central Java	1.08	0.09	1.00	1.25	16	0.000
East Java	1.26	0.30	1.00	2.00	11	0.000
Western region of Indonesia	0.75	0.35	0.50	1.00	2	0.205
Eastern region of Indonesia	0.76	0.21	0.50	1.00	7	0.000
Craftsman's Remuneration						
Yogyakarta	1.00	0.00	1.00	1.00	20	0.000
Jakarta	1.58	0.26	1.20	2.00	13	0.000
West Java	1.38	0.17	1.10	1.60	8	0.000
Central Java	1.08	0.09	1.00	1.30	16	0.000
East Java	1.20	0.16	1.00	1.50	11	0.000
Western region of Indonesia	1.35	0.93	0.70	2.00	2	0.286
Eastern region of Indonesia	1.25	0.52	0.50	2.05	7	0.000

Note: SD = Standard Deviation; N = Valid Number; P = Probability

8.3.1 Comparison of Jakarta, Java and 'Outside of Java'

Jakarta craftsmen have the highest levels of production output for each of the 3 major trades (bricklayers, carpenters, and steel fixers) studied, giving an overall index of 1.33 compared to Yogyakarta (1.00) and Eastern Region of Indonesia (0.68). In fact, craftsmen from Jakarta are about twice as productive as those from 'Outside of Java'. Similarly, craftsmen's working time, levels of skill, and craftsmen's motivation from Java are double those of 'Outside of Java'. However, remuneration is not significantly different between the regions. Overall, severity of productivity problems Outside of Java are twice as bad as those from Jakarta. Each of the variables are now discussed.

8.3.2 The Craftsmen

Although Jakarta craftsmen are largely migrants from other part of Java, their distinguishing feature are that they are younger, talented, and highly motivated craftsmen, commonly employed as 'labour-only' subcontractors on Jakarta sites. Perhaps being 'labour-only' sub-contractors solely responsible for their remuneration, they may not have alternative to working hard. Also, most of the site agents were from Java and in most cases responsible for bringing the workers to Jakarta from other provinces of Java.

Jakarta craftsmen were the highest paid. Craftsmen from Outside of Java are paid higher than Yogyakarta, Central Java, and East Java. Compared to West Java, the Western Region of Indonesia had similar levels of remuneration. On the other hand, the Eastern Region have similar levels of remuneration to that of East Java. As would be expected levels of remuneration reflect proximity between regions. Notably, remuneration levels in West Java and Jakarta are almost the same. Although production output of craftsmen Outside of Java was only half of Java and Jakarta, their remuneration are almost the same. Operative problems are most severe Outside of Java.

8.3.3 The Foremen

Jakarta foremen provide the highest level of supervision compared to other regions, followed by West Java and East Java. Interviews revealed that Jakarta foremen, like their craftsmen, were mostly from East Java and West Java. Foremen from Jakarta and Outside of Java also received higher level of remuneration compared to other regions of Java (see Table 8.3).

Overall, the regions Outside of Java have the most severe productivity problems with the Eastern Region of Indonesia being the worst. This situation is reflected in the general economic development of the region which is considered backward compared to other regions. Since the beginning of the Second Long-term Economic Development Plan in 1992, the Indonesian Government has started paying more attention to the economy including infrastructural development of the Eastern Region of Indonesia.

Table 8.3 Foreman Based Productivity Indices for the Seven Regions of Indonesia.

Level of Supervision	Index	SD	Min	Max	N	P
Yogyakarta	1.00	0.00	1.00	1.00	20	0.000
Jakarta	1.27	0.19	1.00	1.60	13	0.000
West Java	1.18	0.10	1.00	1.30	8	0.000
Central Java	1.04	0.24	1.00	1.10	16	0.000
East Java	1.18	0.16	1.00	1.50	11	0.000
Western region of Indonesia	0.80	0.28	0.60	1.00	2	0.205
Eastern region of Indonesia	0.85	0.25	0.50	1.25	7	0.001
Foreman's Motivation						
Yogyakarta	1.00	0.00	1.00	1.00	20	0.000
Jakarta	1.34	0.20	1.00	1.70	13	0.000
West Java	1.19	0.08	1.05	1.30	8	0.000
Central Java	1.06	0.07	1.00	1.20	16	0.000
East Java	1.17	0.14	1.00	1.50	11	0.000
Western region of Indonesia	0.85	0.21	0.70	1.00	2	0.111
Eastern region of Indonesia	0.84	0.20	0.50	1.10	7	0.000

Note: SD = Standard Deviation; N = Valid Number; P = Probability

Table 8.3 (Continued)

Foreman's Remuneration	Index	SD	Min	Max	N	P
Yogyakarta	1.00	0.00	1.00	1.00	20	0.000
Jakarta	1.62	0.29	1.20	2.00	13	0.000
West Java	1.40	0.18	1.10	1.60	8	0.000
Central Java	1.08	0.10	1.00	1.30	16	0.000
East Java	1.28	0.28	1.00	2.00	11	0.000
Western region of Indonesia	1.35	0.92	0.70	2.00	2	0.286
Eastern region of Indonesia	1.28	0.53	0.50	2.05	7	0.001
Productivity Problem						
Yogyakarta	1.00	0.00	1.00	1.00	20	0.000
Jakarta	0.76	0.09	0.60	0.90	13	0.000
West Java	0.81	0.06	0.70	0.90	8	0.000
Central Java	0.98	0.13	0.80	1.40	16	0.000
East Java	0.82	0.08	0.70	1.00	11	0.000
Western region of Indonesia	1.35	0.12	1.20	1.50	2	0.205
Eastern region of Indonesia	1.53	0.34	1.20	2.00	7	0.000

Note: SD = Standard Deviation; N = Valid Number; P = Probability

8.3.4 Productivity Indices

Table 8.4 presents the Productivity Indices derived from this research for the seven regions. Although the indices do not provide real figures, i.e., the *size* of the production output, they can be used as benchmarks to help contractors estimate labour costs in particular regions when used in conjunction with their past experience of one of the other regions given in the table. The table can help contractors in their labour management by aiding their decisions on whether to employ local or craftsmen from other regions; especially for contractors who may be expanding their services into other regions for the first time.

Table 8.4 Overall Productivity Indices for the Seven Region of Indonesia.*

Variables	Yogya-karta	Jakarta	West Java	Central Java	East Java	Western Region	Eastern Region
Bricklayer's output	1.00	1.35	1.15	1.09	1.20	0.60	0.68
Carpenter's output	1.00	1.32	1.14	1.07	1.25	0.60	0.66
Steelfixer's output	1.00	1.32	1.16	1.07	1.20	0.60	0.65
Craftsman's output	1.00	1.33	1.15	1.08	1.21	0.60	0.66
Productive time in %	1.00	1.32	1.22	1.03	1.15	0.75	0.74
Craftsman's skill	1.00	1.29	1.15	1.07	1.20	0.65	0.69
Craftsman's motivation	1.00	1.32	1.24	1.08	1.26	0.75	0.76
Craftsmen remuneration	1.00	1.59	1.37	1.08	1.20	1.35	1.25
Level of supervisor	1.00	1.27	1.17	1.04	1.14	0.80	0.85
Supervisor motivation	1.00	1.34	1.19	1.06	1.17	0.85	0.84
Supervisor remuneration	1.00	1.63	1.40	1.08	1.28	1.35	1.28
Severity of productivity	1.00	0.82	0.81	0.98	0.82	1.35	1.53

Note: * Yogyakarta Productivity Indices are utilised as a benchmark.

8.4 Variables Influencing Severity of Productivity Problem

In order to explore the relationship between the productivity variables and problems severity, Multiple regression analysis (MRA) was employed (Yogyakarta data are excluded because all variables were scored 1.0; being the benchmark. For analysis sake, let us consider severity of productivity problem the dependent variable; craftsman's production output, working time, skill, motivation, and remuneration; and level of supervision, foreman's motivation, and remuneration as independent variables. Before performing MRA, a correlation analysis between dependent and independent variables was carried out (see Norusis, 1993). Results indicated that 'severity' of craftsmen productivity problem was significantly correlated with 'craftsmen's production output' (with a negative correlation coefficient Rs = -0.52), 'productive working time' Rs = -0.52, 'skill' Rs = -0.51, 'craftsmen motivation' Rs = -0.45, 'level of supervision' Rs = -0.41, and 'foremen motivation' Rs = -0.55. The negative coefficient of correlation imply that the higher the production output, the less severe the problem (see Table 8.5).

Table 8.5 Correlation of Severity of Productivity Problem with Other Variables.

Variables	Craftsman's output	Productive time in %	Craftsman's skill	Craftsman's motivation	Craftsmen remuneration	Level of supervisor	Supervisor motivation	Supervisor remuneration
Severity of productivity	-0.52**	-0.52**	-0.50**	-0.45**	-0.17	-0.41**	-0.55**	-0.19

Note: ** significance at 0.01 level.

To examine which of the independent variables significantly correlated with the dependent variable, a step wise MRA was conducted on the predominant variables influencing the severity of craftsmen productivity problems. After two steps, the MRA was terminated. The first step of analysis provided an equation with supervisor motivation considered the predominant variable affecting problem severity with a coefficient of 0.86 indicating that severity of the problems can be *reduced* by improving foremen motivation. Alternatively, the more motivated the foreman, the less severe the productivity problems. The first stepwise analysis yielded a 70% goodness of fit (R^2).

The second step yielded the equation as shown below, with 'craftsman's production output' included in the significant variables:

$$Y = 2.15 - 0.72\, X_1 - 0.37\, X_2$$

that is, Y represents severity of productivity problem, X_1 and X_2 represent production output and foremen motivation respectively. Note that both partial coefficients are negative (production output = -0.72 and foremen motivation = -0.37). This can be interpreted as follows: the lower the production output and foremen motivation the more severe the productivity problems which is quite logical to follow. The above predictive equation explained 76% of the variability in the productivity problem identified. Other variables may contribute to severity but in this analysis were not found to be significant (Craftsmen skill and craftsmen's motivation with level of significance are 6% and 9% respectively). These variables may potentially explain the remaining 24% of variability in the equation.

8.5 Summary

This chapter investigated productivity related problems in seven regions of Indonesia. Data was collected from sites agents who had experience of working in Yogyakarta and at least in one other region. Using Yogyakarta as a benchmark, the respondents were asked to compare the 12 productivity related variables in the regions.

Jakarta was considered to have the highest number of talented and skilled workers. Results of the productivity analysis indicates that Jakarta construction sites employ better quality construction workers. They provide higher production output, spend longer time productively, better skill, higher motivation, and attain higher remuneration.

East of Java region was shown as having a relatively good construction workforce, followed by West Java, central Java, and Yogyakarta. However, it is difficult to differentiate between Java workers and those from other regions. In the Central Java itself for example, there is a diversity of skilled craftsmen from different sub-regions. Good carpenters are found mostly in certain areas, for example: Kelaten, Jepara, and Purwodadi. Good bricklayers are farmers having built their own houses and neighbour's through

'GOTONG ROYONG' (an unwritten social system that encourages help oneself by first helping others).

This chapter provides a useful insight into the productivity problems and its related variables in major regions of Indonesia, especially for the contractor who would consider to bid for a job in other regions where they are not experienced. More importantly perhaps the research and analysis techniques utilised may have broader application. The derivation of a multiple regression equation can identify variables impacting upon productivity, the ramifications of which, include cost. Such an insight is priceless to contractors, particularly at the bidding stage; and regardless of geographical location! The construction productivity indices organised as a database would be interfaced with the audit system (explained in chapter 10). This would enable the system to provide the user some awareness of deviation of productivity problems within regions of Indonesia.

CHAPTER 9

CHAPTER 9

DEVELOPMENT OF A CONSTRUCTION PRODUCTIVITY AUDIT SYSTEM FOR INDONESIA - IDENTIFICATION OF FACTORS FOR IMPROVING ON-SITE PRODUCTIVITY

9.1 Introduction

Having established productivity problems as of major concern to contractors and clients in Indonesia, an attempt has been made at remedying the problems by developing a construction productivity audit system. Productivity improvement can be approached in various ways. For example, European Construction Institute (ECI) task force on productivity utilised three approaches to confronting the productivity problem in Europe (see Abdul-Kadir and Price, 1995):

1). On-site aspects of productivity;
2). National and industrial factors which ultimately affect site productivity; and
3). Project specific off-site aspects and project conceptual consideration which ultimately affect site productivity.

For these approaches, the construction project is assumed to have the following phases: the conceptual phase; detailed engineering; construction; and hand-over (see ECI, 1994). The focus of this chapter is the construction phase. To achieve efficiency at the construction phase, an on-site productivity improvement strategy is necessary. This strategy would concentrate on the ability of a project manager (PM) to organise construction activities in order to achieve cost effectiveness and to deliver the product on time.

Oxford Dictionary defines *Audit* as an official systematic examination of accounts. Chris Brown, (1994) applied audit to productivity for maintaining good industrial relation and promotion of efficient utilisation of resources. He defines *Audit* as checking the operation of a system or procedure against predetermined set of rules, maintaining the integrity of corporate policies or national / industry standard. Lewington and Williams (1990) developed a productivity audit methodology including identification of problems in banking system. The system can provide early warning for credit worthiness evaluation and feasible point so management can take corrective action; provision of line management at all levels with business oriented reports that assist them in better managing their business and operations.; maintaining an effective working relationship with the external auditors and the examiners from regulatory agencies to ensure that all audits are performed in most efficient manners possible.

British Standard Institution (BS 3138, 1992) through its standard glossary of terms used in management services defined audit and system. as follows: 1) *Procedure audit* is defined as an application of soft systems methodology to establish the current levels of efficiency and effectiveness of an organisation's procedures as a prerequisite to effecting improvement. 2) *Decision support system (DSS)* is defined as a system for abstracting and integrating the results from decision trees, decision matrices and other sources to probe the variation outcomes. This may be done manually or with computer assistance. 3) *Expert system* is defined as a computer programme that uses the programming techniques of artificial intelligence, especially those techniques developed for problem solving to interrogate data and deduce results within parameters programmed into it. 4) *Intelligent knowledge based system (IKBS)* is defined as an expert system built up from knowledge acquired from human experts to receive information about a situation and deduce results appropriate to that condition. 5) *Management audit (Operations audit)* is defined as a systematic examination of policies and practices within an organisation to assess their effectiveness.

Construction productivity auditing is the use of audits for the identification of productivity problems on construction site. Auditing informs actions to reduce or eliminate particular identified problems at the primary level. If further improvement is considered to be needed, the system can provide advice (at optimisation level) on how to improve on-site productivity, and recommend best practices.

In developing an audit system for construction productivity in Indonesia, factors influencing on-site productivity must be recognised. Factors identified have been grouped into four categories: (1) Methods and Technology, (2) Site Management, (3) Working Environment, and (4) Human Factors. These form the basis of a structured questionnaire survey and interviews aimed at seeking ways for improving productivity from project managers and construction experts from two major cities in Indonesia, namely Yogyakarta and Jakarta.

This chapter aims at prioritising the factors influencing *on-site* productivity improvement which have been identified by many researchers (see Olomolaiye and Ogunlana, 1989; Maloney, 1990, Liu, 1991; Kaming, 1992), and are considered to be controllable by project managers. External (off site) factors that may influence on-site productivity (for example: change orders from clients, and company cash flow) are outside the scope of this study. Firstly in this chapter, factors influencing on-site productivity are briefly described. The four types of resource utilisation defined for this study are also explained. Results of an overall priority ranking exercise and category ranking of the factors studied, are discussed. Impact of the factors for improving on-site productivity upon resource utilisation is examined. Finally a comparison of the priority rankings provided by both the project managers and experts is presented.

9.2 Factors for Improving On-site Productivity

On-site productivity improvement factors can be classified into four categories: Methods and Technology (C1), Site Management (C2), Working Environment (C3), and Human Factors (C4) consisting of 4, 6, 6, and 7 factors respectively. These 23 factors have been extensively investigated in previous studies (see Olomolaiye and Ogunlana, 1989; Liu, 1991), hence they are now only briefly discussed below.

9.2.1 Methods and Technology (C1)

This category consisted of four factors, namely: Engineering Design (F11), Methods of Construction (F12), Sequence of Works (F13), and Work Measurement (F14). The following paragraphs briefly explain and define the factors and the respective parameters which constitute their measurement.

Engineering Design (F11)

This is defined as evaluating design buildability, including, checking the completeness of shop drawings in terms of concise layout and detail as well as accuracy and correct scale. Four basic principal measurements for engineering design are: Potential for achieving time savings, structural safety, cost saving, and ease of buildability. The application of these measurements is conducted to compare actual project outcomes with standards established from past experience. Accurate drawings, detail, and clearly stated scales/dimensions supported by buildability are generally regarded as characteristics of good engineering design. Although these measures are all based on subjective judgement, experienced and knowledgeable project managers can provide accurate ratings on how important these efforts can be in improving on-site productivity (see Stewart, 1989).

Method of Construction (F12)

No single method of construction can be universally regarded as superior in all conditions. Construction methods need to be appropriately selected to provide the most productive result, based on a cost effective analysis of safety, cost, time, practicability, achievable quality and the availability and utilisation of resources. Good construction methods can improve on-site productivity through applying; (1) standardisation of components in terms of type of material, and unit of measurement; (2) modularisation and; (3) pre-assembly and prefabrication of components, see Construction Management Committee of the ASCE Construction Division, (1991).

Sequence of Work (F13)

Knowledge of the construction process is paramount to select and implement an appropriate sequence of work. Improper sequencing can generate reworks. Reworks increase cost and therefore reduce productivity. The correct delivery of resources (including detailed shop drawings, materials, equipment, and labour) are regarded as one of the principles for measuring an effective good sequence of work. Other aspects for good work sequencing practices include: ensuring adequate design/engineering lead time (to be ahead of construction activities) and an adequate supply function.

Work Measurement (F14)

Work Measurement is regarded as data recorded to measure resource utilisation on a current job, which can then also be used for estimating and planning purposes on future jobs. If this is done properly by means of regular use of standard methods (e.g. work study), and quality circle (Plan, Do, Check. Action), on site productivity may be properly monitored and necessary action taken to remedy problems at an early stage (i.e., proactive vis-à-vis reactive policy).

9.2.2 Site Management (C2)

This category consists of six factors: Planning and Scheduling (F21), Site Layout (F22), Site Communication (F23), Material Management (F24), Equipment Management (F25), and Manpower Management (F26). Each is briefly explained in the following paragraphs.

Planning and Scheduling (F21)

This plays an important role in achieving project objectives such as completion on-time, within budget, and to specified standard of quality. There are six plans which can be incorporated into schedules: (1) Construction schedule - sequential activities for physical construction of project components; (2) Logistic schedule - material and equipment required, including transportation, warehousing and sequence of site arrivals, and as appropriate, acquisition of land for structures (legal aspects of land development); (3) Manpower schedule - recruitment, training and personnel placement activities; (4) Procurement schedule - procurement and contracting events for obtaining project goods and expenditures; (5) Financial schedule - sequence for commitment of funds and timing of the project expenditure; and (6) Evaluation plan - data collection activities and timing of review actions. This also includes updating the other schedules if there is any change or deviation of the actual progress to that planned (see Little, 1988; Oglesby, et.al. 1989).

Site Layout (F22)

A good site layout can improve productivity through (1) balancing the capacity and movement of equipment; (2) providing sufficient basic physical needs for workers; (3) materials handling by arranging the movement of materials over the possibly shortest distance; (4) reducing in-process inventories by balancing, effective scheduling, and good stockroom, and storage area location; (5) making safe site layouts - providing clear aisle, lighting, and exit plans in case of emergencies; (6) maximising manpower utilisation by eliminating unnecessary movement and confusion, and; (7) simplifying supervision and making it more effective, through well defined areas of responsibility, relative to the physical arrangement of plant facilities and equipment (see Gray and Little, 1985; Forster, 1992; Tommelien et.al.,1992).

Site Communication (F23)

Site instruction, co-ordination, and feedback are regarded as site communication in written forms. They include (1) Materials received sheets, (2) Material/plant transferred sheets, (3) Programme and progress reports, (4) Variation orders, (5) Subcontractors claims, (6) Valuation of work done, (7) Time sheets (8) Wages sheets (9) Bonus sheets (10) Notification requests to Government Agency for inspection, (11) Notification requests under Health and Safety at Work, (12) Details of disciplinary warning to operatives/employees, (13) Accident reports and statistics. All these undoubtedly affect productivity and therefore should be properly managed (see Olson, 1982; Forster, 1992).

Material Management (F24)

Planning, delivery, handling, and eliminating waste of material are common material management issues either in developing or developed country (see Olomolaiye, 1991, Proverbs et.al. 1995). Material delivery to site is a critical productivity related aspect which demands the introduction of a carefully developed system of monitoring and control as early as possible. Such a system needs to be detailed and comprehensive; and should cover the total scope of material items for the works. It requires regular updating with realistic delivery time scales. Furthermore, material deliveries must satisfy the contract programme and recognise the need to maintain practical levels of human and equipment resources which will, in turn, allow the required progress to be achieved. In addition to delivery, material identification and storage requirements should be clearly determined before procurement (see Johnston, 1981; Illingworth and Thain, 1988).

Equipment Management (F25)

Equipment selection in terms of type, size, and numbers can be different for a particular construction. For example, equipment needs for high-rise construction, which are commonly located in congested urban areas are generally tower crane, concrete pump, vertical hoist, and batching plant. Besides the need for balancing the capacity and work load for each piece of equipment, they should also be kept optimal and ready for use in terms of applying preventive maintenance management principles such as regular checking, spare parts preparation and renewal. (See Harris, 1989).

Manpower Management (F26)

Manpower management includes resource aggregation and resource levelling, especially for scarce craftsmen such as plumbers, and electricians. Current practices in manpower management has transferred responsibility from main contractor to labour only sub-contractors who manage their own workforce. Furthermore, the practices of sub-contracting and outsourcing for specialists (i.e. electrical and mechanical) have flourished for the last two decades in Indonesia. However, main contractors have to consider effective resource lévelling in terms of continuity of job for their workers (see Harris and McCaffer, 1989).

9.2.3 Working Environment (C3)

The factors that make up this category are: Site Safety (F13), Physical Environment (F32), Supervision Quality (F33), Job Security (F34), Job Training (F35), and Participation (F36).

Site Safety (F31)

Hinze and Harrison, (1981) identified actions needed to ensure on-site safety through: (1) employing a safety director at corporate level of a construction firm; (2) conducting regular safety exercises and meetings for site safety representatives; (3) giving authority to field safety representatives to stop work if unsafe or extremely hazardous activities occur, (4) providing special safety related training for the field representatives such as first aid; (5) rewarding for excellent safety performance; (6) conducting standard reports for accident/injury; (7) providing medical examination of the workers' physical conditions; (8) performing inspection on-site by corporate level safety manager, and; (9) providing safety devices such as safety belts, safety helmets, boots, goggles, etc. (see Harijanto 1993).

Physical Environment (F32)

External physical conditions affecting productivity include aspects such as temperature, rain, ground conditions, dust, and noise. Internal aspects of the physical environment include fatigue due to the frequency of overtime working. Indeed, by reducing the physical constraints and taking care of the physical needs of workers production rates may be improved. For instance, providing drinking water and toilet near their work places can reduce unproductive time. Providing simple sheltering for external structural work may also be considered in improving the work environment.

Supervision quality (F33)

Supervision quality can be measured in terms of foreman leadership. There are 5 aspects that can be applied as indicators of good leadership: (1) problem solving - this includes creativity in problem solving, making decisions quickly, and taking sub-ordinates opinion into account; (2) administration - this includes careful planning of the works, concern about site safety, layout work quickly; (3) supervision and team management - this includes giving clear direction, accepting responsibility for work; (4) interpersonal relationship - good at motivating people, willing to accept suggestion, and being proud of work and crews. (5) Personal quality - this includes having self confidence, no favouritism amongst sub-ordinates, and being evenly tempered (Oglesby, et.al, 1989).

Job Security (F34)

Self employed workers are very concerned with their job security. By providing job security and continuity of work, workers can concentrate upon performing their job, consequently, productivity is improved (see Maloney, 1987a; Liu, 1990).

Training (F35)

Training must be structured for all site management and needs to concentrate on leadership skills, and job requirements. Adequate induction training will ensure familiarisation with site specific requirements and awareness of company policies on aspects such as safety, quality, and procedures relative to employment terms and conditions. Re-training in new methods and in the use of computers is vital in supplementing existing knowledge and experience (see Maloney and McFillen, 1988).

Good practices for workforce skill development and training include the following: (1) Introduction of practical skill tests for all trades prior to employment; (2) development of multiple skilled tradesmen from the apprenticeship stage; (3) encouragement of trade flexibility through training in new methods and practices followed by allocation of suitable work tasks; (4) re-training in new methods, skills and procedures to supplement existing skill levels and experience.

Worker participation (F36)

Participation in decision making is one of the most effective behavioural science concepts for improving job satisfaction and productivity. Borcherding (1977) insisted that productivity may improve by providing chances for foremen, for participating in decision making such as establishment of job policies for coffee breaks and crew sizes. Maloney (1986) found that the level of participation provided by foremen/managers to the workers can stimulate worker performance. Worker participation can take many forms, for instance, quality circle, in which worker and management meet and talk. If workers are allowed to identify and help solve problems affecting their work, it may lead, among other things, to cost-saving ideas, more job satisfaction, more attention to safety, more cohesive work teams, and improved quality control. Indeed, this kind of participatory decision making may well be the most effective method yet devised to improve the motivation of foremen and craftsmen.

9.2.4 Human Factors(C4)

This category consists of 7 factors which could be classified as motivation factors. They are: level of pay for workers (F41), job satisfaction (F42), incentives (F3), fringe benefits (F44), foremen craftsmen relationships (F45), peers relationship (F46), and absenteeism (F47).

Level of Pay (F41)

Pay levels for construction workers are low in Indonesia indicated by labour cost that consists of about 17% from total construction cost (see Kaming, et. al., 1995a). Some construction workers seek to work overtime in order to earn more money. Low payment is also associated with low skill and low productivity, but providing higher pay does not necessary achieve better productivity. The workers' performance would need to be assessed in order to be able to adjust pay level to productivity.

Satisfaction (F42)

Job satisfaction is a key aspect in employee motivation and promotion of productivity. Using Expectancy Theory, Maloney and McFillen (1985) investigated the valence of and satisfaction with job outcomes of construction workers and found that low satisfaction could lead directly to tardiness, absenteeism, turnover and grievances, and indirectly to decrease productivity. He further recommended that contractors must take action on factors that are valence, i.e., important to workers, and for which the worker report low satisfaction. By taking such actions, contractors would be able to reduce dysfunctional behaviour, increase worker productivity, and make the work experience more rewarding and satisfying for the workers.

Incentives (F43)

Financial incentives must be applied using an earned value concept and bonuses should never be 'automatically' awarded. The work done must be easily and accurately measured. Laufer and Borcherding, (1981) had canvassed the opinion of teams of experts who conclude that under the right conditions, incentive schemes would increase labour productivity. Incentive schemes are more effective when applied to small teams of workers. Displaying team performance can also encourage productivity improvements through increased competition.

Fringe Benefits (F44)

Fringe benefits apply to permanent site staff at certain levels, but are seldom applied to construction workers since most are now self employed. On certain occasions, such as the Moslem Holiday (Lebaran) and New Year, Indonesian contractors grant 'gifts' rather than 'bonus' to their workers. They also provide travelling costs in order to ensure workers return to work after holidays.

Foremen - Craftsmen Relationship (F45)

This relationship can improve two way communications: Instruction (Foreman to craftsmen) and feedback or bottom up suggestions (craftsmen to foreman). The impact of the foremen-craftsmen relationship upon on-site productivity has not been fully investigated. However, the influence of foremen leadership factors on craftsmen' motivation have been identified by Maloney (1988) as a means of increasing motivation which in turn can improve productivity. Good working relationships with and within a crew (supervisors, workmen, and inspectors) are helpful; poor relationships cause dissatisfaction.

Peer Relationships (F46)

Peer relationships have two sub-groups; (1) amongst craftsmen and; (2) amongst foremen. Good relationships can stimulate co-operation spirit, and in turn, harmonise the work sequence. Borcherding and Oglesby (1974) recommended that site management should maintain close personal contact with foremen; attempt to eliminate confrontations between foremen of other trades; use weekly scheduling meetings to promote understanding, co-operation, and trust among foremen; select a field supervisor that would get along with the job; and initiate educational efforts to promote better relationships.

Absenteeism (F47)

Absenteeism has been found to be important and to be one of the most frequently occurring productivity problems in the construction industry of Indonesia (see Chapter 5). Providing adequate facilities/accommodation for workers on or near to the construction site was the most common way of avoiding absenteeism in Indonesia - to avoid absenteeism of the workers. Construction Industry Cost Effectiveness (1983) indicated that absenteeism and labour turnover can hit construction severely hard for three reasons: 1) work must generally be performed in a planned sequence; 2) every member of a scheduled crew often must be on the job for the work to proceed; and 3) expensive rented equipment may be idled if a key employee fails to show up. Obviously, reducing absenteeism and labour turnover can lead to reduced labour cost, hence improvements in productivity.

Hinze et.al (1985) recommended that managers; (1) stress their displeasure in workers absenteeism; (2) provide challenging work for the craftsmen; (3) promote cohesive teamwork; and (4) by providing accommodation to avoid frequency of returns to site for trades, .

9.3 Resource Utilisation

Sanvido (1988) classified resources into two categories:

1. Totally consumed resources - those that are wholly consumed or whose value as an individual resource decreases to zero during the construction process. These resources are replenished by bringing more onto the site. They comprise man-hours, material, energy, and information.
2. Partially consumed resources - those that have a residual value that is less than their original value. The value can be replenished by activities such as maintenance and repair. Typical resources of this type are equipment, temporary facilities such as repeatable concrete formwork, scaffold, and tools.

Partially consumed resources can be regarded as part of those totally consumed because equipment, and temporary facilities can be hired, or their unit cost can be calculated against time, and salvage values if they are owned. Therefore, the approach used in this chapter classifies resource utilisation into four categories: time, material, labour, and plant utilisation.

9.4 Result and Discussion

9.4.1 Relative Importance Indices

Twenty six PMs completed questionnaires and were subsequently interviewed. Tables 9.1 present the degree of importance that the project managers assigned to on-site productivity improvement factors. A value of 1 indicates 'very important', 0.75 'important', 0.50 'little importance', 0.25 'not important' and zero 'not applicable'. Although repetitive ranking was allowed, a visual inspection shows no apparent use of a particular rank across the factors by any one respondent. This indicates that thoughtful assessments were made and that the project managers provided their considered opinions on the ranking of factors as requested.

9.4.2 Agreement of Priority Rankings

The priority ranking using relative importance indices was tested using Kendall concordance analysis. The ordinal measurement provided by the respondents were then converted to ranking data (automatically by SPSS when Kendall concordance method is applied). The analysis provides the priority ranking of factors studied based on the ranking data (see Kendall, 1970; Siegel and Castellan, 1988; Nkado, 1995). It was also used to test the null hypothesis that respondents (26 project managers) were independent or unrelated at 5% significance level. Table 9.2 shows the results of the concordance test for project managers. The mean rank of each factor was computed after standardising the ranks given by each respondent to the factors. The coefficient of concordance for PMs (w = 0.39) was very significant (sig. = 0.000).

The low probability associated with the observed value of Kendall concordance coefficient enable us to reject the null hypothesis that respondents' ratings with respect to PMs are unrelated to each other. We may therefore conclude with confidence that the agreement among the PMs is higher than it would be by chance had their rankings been random or independent. Thus, there is good degree of consistency among respondents in prioritising the factors for improving productivity.

Table 9.1 Ranking of Factors by Respondents

Resp	F11	F12	F13	F14	F21	F22	F23	F24	F25	F26	F31	F32	F33	F34	F35	F36	F41	F42	F43	F44	F45	F46	F47
1	1.00	1.00	1.00	1.00	0.75	1.00	0.75	1.00	1.00	1.00	0.75	0.75	1.00	1.00	1.00	0.75	0.75	1.00	0.75	0.75	1.00	1.00	1.00
2	1.00	1.00	1.00	0.75	1.00	1.00	1.00	1.00	0.75	1.00	0.75	0.75	0.75	1.00	.	1.00	1.00	1.00	1.00	0.75	0.75	0.75	0.75
3	1.00	1.00	0.75	0.75	1.00	1.00	0.75	0.75	0.75	0.75	0.75	0.75	1.00	0.50	0.75	0.75	0.75	0.75	0.75	0.50	1.00	0.75	0.75
4	0.75	0.75	1.00	0.75	1.00	0.75	1.00	0.75	0.75	1.00	0.75	0.75	1.00	0.75	0.50	0.50	0.75	1.00	0.75	.	1.00	1.00	0.75
5	1.00	1.00	1.00	1.00	1.00	1.00	0.75	1.00	1.00	1.00	1.00	0.75	1.00	1.00	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
6	1.00	1.00	0.75	0.75	1.00	0.75	0.75	1.00	0.75	0.75	0.50	0.75	1.00	0.75	0.75	0.75	0.75	1.00	0.50	0.75	0.75	0.75	0.75
7	1.00	0.75	1.00	0.75	1.00	0.75	0.75	0.75	1.00	0.75	0.75	0.75	1.00	0.75	0.75	0.75	0.50	0.75	0.75	0.75	1.00	0.75	0.75
8	0.75	0.75	1.00	1.00	1.00	0.75	0.75	1.00	0.75	1.00	0.75	0.75	1.00	0.75	0.75	1.00	0.75	0.75	1.00	0.50	0.75	0.75	0.75
9	1.00	1.00	1.00	0.75	1.00	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.50	.	.	0.75	0.75	.00	0.75	0.75	0.75	0.75
10	1.00	1.00	1.00	1.00	1.00	0.75	0.75	1.00	0.50	0.75	1.00	0.75	1.00	0.75	0.50	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
11	1.00	1.00	1.00	1.00	1.00	0.75	0.75	1.00	0.75	1.00	1.00	0.75	0.75	0.75	0.25	0.75	0.75	0.75	0.75	0.75	1.00	1.00	0.75
12	1.00	1.00	1.00	1.00	1.00	1.00	0.75	0.75	0.75	0.75	1.00	0.50	1.00	1.00	1.00	0.75	1.00	1.00	0.75	0.50	0.75	1.00	1.00
13	0.75	1.00	0.75	1.00	1.00	0.75	0.75	1.00	0.75	0.75	0.75	1.00	1.00	1.00	1.00	0.75	0.75	1.00	0.75	0.75	0.75	0.50	0.75
14	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.75	1.00	1.00	1.00	1.00	0.75	0.75	0.75	1.00	1.00	0.75	0.50	1.00	0.75	1.00
15	1.00	1.00	1.00	1.00	1.00	0.75	1.00	1.00	1.00	1.00	0.75	0.25	0.75	0.25	0.75	1.00	0.50	0.75	0.75	0.75	1.00	0.75	1.00
16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.75	1.00	0.75	1.00	0.50	0.75	0.50	1.00	0.75	0.50	0.75	1.00	0.75	0.75
17	1.00	1.00	1.00	0.75	1.00	1.00	1.00	0.75	0.75	0.75	0.50	0.50	1.00	0.75	0.50	0.75	0.75	0.50	0.50	0.75	1.00	1.00	0.75
18	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.75	1.00	0.75	1.00	1.00	0.75	1.00	1.00	0.75	1.00	0.75	0.75
19	1.00	1.00	1.00	1.00	1.00	0.75	0.75	0.75	0.75	0.75	0.75	0.50	0.75	0.50	0.50	0.75	0.75	0.50	0.75	0.50	0.50	0.50	0.50
20	1.00	1.00	1.00	0.75	1.00	1.00	1.00	0.75	1.00	0.75	0.75	0.75	1.00	1.00	0.50	1.00	1.00	0.75	0.50	0.50	0.75	1.00	0.75
21	1.00	1.00	1.00	1.00	1.00	0.75	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
22	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.75	1.00	0.75	1.00	0.75	1.00	0.75	1.00	0.50	0.75	0.50	0.50	0.75	1.00	1.00	0.75
23	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	1.00	0.75	0.50	0.75	0.75	0.75	0.75	0.50	0.75	0.75	0.75
24	1.00	1.00	1.00	1.00	1.00	0.75	0.75	1.00	1.00	1.00	0.75	0.75	1.00	0.75	0.75	0.75	0.75	0.75	.	0.75	0.75	0.75	0.75
25	1.00	1.00	1.00	0.75	1.00	0.75	0.75	1.00	1.00	1.00	1.00	0.75	1.00	0.75	0.75	1.00	0.75	0.50	0.75	0.75	0.75	0.75	0.50
26	1.00	1.00	0.75	0.50	1.00	1.00	1.00	1.00	1.00	1.00	0.75	0.50	1.00	0.75	0.75	0.50	0.50	0.75	0.75	0.75	0.75	0.75	0.75
Sum	25.25	25.25	25.00	23.25	25.75	22.75	22.50	23.75	22.50	23.00	21.75	18.50	24.75	19.50	17.25	19.25	20.00	20.50	17.50	17.00	22.00	20.75	20.00
Mean	0.97	0.97	0.96	0.89	0.99	0.88	0.87	0.91	0.87	0.88	0.84	0.71	0.95	0.75	0.72	0.77	0.77	0.79	0.70	0.68	0.85	0.80	0.77

Table 9.2 Project Managers' Priority Ranking of On-site Productivity Improvement Factors.

Code	Factors	Mean Rank	Priority Rank
F21	Planning and Scheduling	17.63	1
F13	Sequence of Works	17.35	2
F12	Methods of Construction	16.94	3
F33	Supervision Quality	16.62	4
F11	Engineering Design	16.52	5
F14	Work Measurement	15.04	6
F24	Material Management	14.77	7
F26	Manpower Management	13.96	8
F22	Site Layout	12.88	9
F23	Site Communication	12.48	10
F25	Equipment Management	12.85	11
F31	Site Safety	12.46	12
F45	Foreman-Craftsmen Relationship	12.21	13
F46	Peer Relationship	10.29	14
F42	Satisfaction	9.90	15
F47	Absenteeism	9.58	16
F36	Workers Participation	8.81	19
F41	Level of Pay	9.13	17
F34	Job Security	8.83	18
F32	Physical Environment	7.60	20
F35	Job Training	7.52	21
F43	Incentive	6.67	22
F44	Fringe Benefit	5.96	23

Cases	W	chi-square	D.F	Significance
26	0.3913	223.8248	22	0.0000

9.4.3 The Predominant Factors

'Planning and scheduling' was ranked the most predominant factor for improving productivity in Indonesia supporting studies by Arditi (1986) on the United States construction productivity improvement in mid 80s; Arditi and Mochtar (1996) on

Indonesian construction productivity improvement carried out in 1992. 'Sequence of work' was ranked 2nd, and 'method of construction' 3rd.

Note that the first ten factors were dominated by factors from the first and second categories. Only 'supervision quality' from the third category was ranked highly (4th). This indicates that the factors in the first two categories plus 'supervision quality' are given priority in improving on-site productivity.

9.4.4 Improving On-site Productivity by Type of Resource

Tables 9.3 presents the resource utilisation indices and ranking of factors for improving on-site productivity by type of resources as identified by project managers The indices indicate the degree of influence that each factor has upon the four production resources (1 = very high influence to 0 = no influence at all), whilst the ranking indicates the impact of each factor upon the effective use of resources (3 = most impact to 1 = least impact).

The project managers considered time the most important resource and ranked it 1st of 16 factors (3 factors of category 1; 3 of category 2; 3 of category 3; and 7 of category 4). Material was considered most important in only one factor in category 2; labour in 6 factors (one factor in each category 1 and 2, 4 factors of category 3); and plant 2 factors both of category 2.

Time Utilisation - With regard to time utilisation, the PMs ranked 'sequence of work' as being paramount (see Table 9.4). Both 'method of construction', and 'planning and scheduling' ranked second. A correlation analysis carried out for overall data found that 'material management' and 'method of construction' are significantly correlated (R_s = 0.75). Improvement in method of construction may also improve the effectiveness in material management. We may therefore infer that 'method of construction', 'sequence of works', and 'planning and scheduling' are paramount to productivity improvement with respect to time utilisation.

Table 9.3 Project Managers' Indices and Ranking of On-site Productivity Improvement Factors by Type of Resource.

Factor		Time	Material	Labour	Plant
	Method and Technology				
Engineering Design	Index	0.95	0.90	0.87	0.86
	Rank	1	2	3	4
Methods of Construction	Index	0.99	0.95	0.94	0.95
	Rank	1	2	4	2
Sequence of Work	Index	1.00	0.92	0.90	0.90
	Rank	1	2	3	3
Work Measurement	Index	0.95	0.95	0.97	0.95
	Rank	2	2	1	2
	Site Management				
Planning and Scheduling	Index	0.99	0.96	0.95	0.97
	Rank	1	3	4	2
Site Layout	Index	0.91	0.91	0.88	2.85
	Rank	2	2	4	1
Site Communication	Index	0.94	0.82	0.83	0.83
	Rank	1	4	2	2
Material Management	Index	0.94	0.97	0.86	0.82
	Rank	2	1	3	4
Equipment Management	Index	0.95	0.85	0.90	0.97
	Rank	2	4	3	1
Manpower Management	Index	0.95	0.87	0.95	0.86
	Rank	1	3	1	4
	Working Environment				
Safety	Index	0.72	0.59	0.76	0.64
	Rank	2	4	1	3
Physical Environment	Index	0.71	0.56	0.73	0.60
	Rank	2	4	1	3
Supervision Quality	Index	0.99	0.92	0.95	0.90
	Rank	1	3	2	4
Job Security	Index	0.71	0.69	0.71	0.68
	Rank	1	3	1	4
Job Training	Index	0.65	0.67	0.72	0.67
	Rank	4	2	1	2
Worker Participation in Planning	Index	0.74	0.69	0.73	0.71
	Rank	1	4	2	3
	Human Factors				
Level of Pay	Index	0.81	0.71	0.77	0.72
	Rank	1	4	2	3
Satisfaction	Index	0.87	0.77	0.78	0.77
	Rank	1	3	2	3
Incentive	Index	0.71	0.58	0.64	0.60
	Rank	1	4	2	3
Fringe Benefit	Index	0.73	0.62	0.68	0.63
	Rank	1	4	2	3
Foremen-Craftsmen Relationship	Index	0.88	0.81	0.85	0.73
	Rank	1	3	2	4
Peer Relationship	Index	0.86	0.78	0.78	0.77
	Rank	1	2	2	4
Absenteeism	Index	0.90	0.67	0.81	0.73
	Rank	1	4	2	3

Table 9.4 Project Managers' Priority Ranking of Factors Influencing Time Utilisation

Code	Factors	Mean Rank	Priority Rank
F13	Sequence of Works	15.50	1
F12	Methods of Construction	15.40	2
F21	Planning and Scheduling	15.40	2
F33	Supervision Quality	15.12	4
F11	Engineering Design	14.40	5
F14	Work Measurement	14.38	6
F26	Manpower Management	14.38	6
F25	Equipment Management	14.33	8
F24	Material Management	13.92	9
F23	Site Communication	13.88	10
F22	Site Layout	13.13	11
F47	Absenteeism	12.75	12
F45	Foreman-Craftsmen Relationship	12.21	13
F46	Peer Relationship	11.81	14
F42	Satisfaction	11.75	15
F41	Level of Pay	9.94	16
F36	Workers Participation	9.40	17
F43	Incentive	8.73	18
F44	Fringe Benefit	8.08	19
F35	Job Training	7.92	20
F31	Site Safety	7.88	21
F32	Physical Environment	7.85	22
F34	Job Security	7.81	23

Cases	W	chi-square	D.F	Significance
26	0.3187	182.2922	22	0.0000

Table 9.5 Project Managers' Priority Ranking of Factors Influencing Material Utilisation.

Code	Factors	Mean Rank	Priority Rank
F24	Material Management	16.69	1
F21	Planning and Scheduling	16.58	2
F14	Work Measurement	16.29	3
F12	Methods of Construction	16.15	4
F33	Supervision Quality	15.63	5
F13	Sequence of Works	15.40	6
F22	Site Layout	14.88	7
F11	Engineering Design	14.73	8
F26	Manpower Management	14.21	9
F25	Equipment Management	13.06	10
F23	Site Communication	12.54	11
F45	Foreman-Craftsmen Relationship	12.15	12
F46	Peer Relationship	11.37	13
F42	Satisfaction	11.00	14
F35	Job Training	9.96	15
F36	Workers Participation	9.69	16
F34	Job Security	9.52	17
F41	Level of Pay	9.13	18
F47	Absenteeism	8.60	19
F43	Incentive	7.56	20
F31	Site Safety	7.29	21
F44	Fringe Benefit	6.87	22
F32	Physical Environment	6.42	23

Cases	W	chi-square	D.F	Significance
26	0.3586	205.1019	22	0.0000

Table 9.6 Project Managers' Priority Ranking of Factors Influencing Labour Utilisation.

Code	Factors	Mean Rank	Priority Rank
F14	Work Measurement	16.25	1
F21	Planning and Scheduling	15.65	2
F26	Manpower Management	15.40	3
F33	Supervision Quality	15.35	4
F12	Methods of Construction	15.27	5
F25	Equipment Management	14.00	6
F13	Sequence of Works	13.81	7
F22	Site Layout	13.35	8
F11	Engineering Design	13.17	9
F24	Material Management	12.75	10
F45	Foreman-Craftsmen Relationship	12.06	11
F23	Site Communication	11.75	12
F47	Absenteeism	10.81	13
F35	Job Training	10.63	14
F46	Peer Relationship	10.52	15
F42	Satisfaction	10.44	16
F31	Site Safety	10.13	17
F36	Workers Participation	9.92	18
F32	Physical Environment	9.77	19
F41	Level of Pay	9.75	20
F34	Job Security	8.85	21
F43	Incentive	8.50	22
F44	Fringe Benefit	7.87	23

Cases	W	chi-square	D.F	Significance
26	0.2155	123.2895	22	0.0000

Table 9.7 Project Managers' Priority Ranking of Factors Influencing Plant Utilisation.

Code	Factors	Mean Rank	Priority Rank
F25	Equipment Management	17.17	1
F21	Planning and Scheduling	17.04	2
F22	Site Layout	16.27	3
F14	Work Measurement	16.25	4
F12	Methods of Construction	16.15	5
F13	Sequence of Works	14.75	6
F33	Supervision Quality	14.79	7
F26	Manpower Management	13.98	8
F11	Engineering Design	13.44	9
F23	Site Communication	12.73	10
F24	Material Management	12.58	11
F42	Satisfaction	11.15	13
F46	Peer Relationship	11.08	14
F36	Workers Participation	10.13	15
F47	Absenteeism	10.08	16
F45	Foreman-Craftsmen Relationship	9.79	17
F41	Level of Pay	9.71	18
F34	Job Security	8.98	19
F31	Site Safety	8.06	20
F43	Incentive	7.94	21
F44	Fringe Benefit	7.15	22
F32	Physical Environment	6.79	23

Cases	W	chi-square	D.F	Significance
26	0.3663	209.5420	22	0.0000

Material Utilisation - With respect to material utilisation, 'Material management', 'planning and scheduling', and 'work measurement' were cited as paramount by the PMs. (see Tables 9.5). Results of correlation analysis for overall data showed that 'planning and scheduling' has significant correlation coefficients with: (1) 'supervision quality' (R_s = 0.53); (2)

'sequence of work' (R_S = 0.50); and (3) 'material management' (R_S = 0.38). We may, thus, infer that improvement in planning a construction project's activities should include increased quality in supervision, organising works in proper sequence, and ensuring material availability on job sites.

Labour Utilisation - With regards to labour utilisation, 'Work measurement', 'planning and scheduling', and 'manpower management' were cited as being paramount by the PMs. (see Tables 9.6). Results of analysis using overall data showed that 'planning and scheduling' had significant correlation coefficients with: (1) 'sequence of work' (R_S = 0.49); (2) 'manpower management' (R_S = 0.53); and (3) 'site layout' (R_S = 0.46). These results indicate that for good construction 'planning and scheduling' to be achieved with respect to effective labour utilisation it would need to be supported by; effective manpower management; good sequence of works; and efficient of organising / arrangement of site layout.

Equipment Utilisation - 'Equipment management', 'planning and scheduling', and 'site layout' were cited as paramount to effective plant utilisation by the PMs. (see Tables 9.7). Results of correlation analysis showed that only 'planning and scheduling' was significantly correlated with 'sequence of works' (R_S = 0.41). We may imply that good 'construction planning', 'equipment management', and 'engineering design' are paramount to productivity improvement with respect to plant utilisation.

Table 9.8 exhibits a summary of the priority ranking of factors influencing resource utilisation by the respondents. Overall, factors in the first two categories (Method and Technology, and Site Management) had higher rankings than those of categories three and four with respect to resource utilisation. The sum of the rankings indicate the overall ranking of factor for improving productivity. The smaller the value, the higher the ranking. Ten most influencing factors were: 'planning and scheduling' ranked 1st, followed by 'methods of construction', 'work measurement', 'sequence of works', 'supervision quality', 'engineering design', 'manpower management', 'material management', and 'site layout'. Notably 'supervision quality' (from the third category) is included in the ten most important factors. Human factors seem to have less impact on resource utilisation compared to the other categories. The first five factors influencing effective utilisation of each resource are now discussed:

Table 9.8 Summary of Project Managers' Priority Ranking of Factors Influencing Time, Material, Labour, and Plant Utilisation.

	Factors	Time	Material	Labour	Plant
F11	Engineering Design	5	8	9	9
F12	Methods of Construction	2	4	5	5
F13	Sequence of Works	1	6	7	6
F14	Work Measurement	6	3	1	4
F21	Planning and Scheduling	2	2	2	2
F22	Site Layout	11	7	8	3
F23	Site Communication	10	11	12	10
F24	Material Management	9	1	10	11
F25	Equipment Management	8	10	6	1
F26	Manpower Management	6	9	3	8
F31	Site Safety	21	21	17	20
F32	Physical Environment	22	23	19	23
F33	Supervision Quality	4	5	4	7
F34	Job Security	23	17	21	19
F35	Job Training	20	15	14	17
F36	Workers Participation	17	16	18	15
F41	Level of Pay	16	18	20	18
F42	Satisfaction	15	14	16	13
F43	Incentive	18	20	22	21
F44	Fringe Benefit	19	22	23	22
F45	Foreman-Craftsmen Relationship	13	12	11	17
F46	Peer Relationship	14	13	15	14
F47	Absenteeism	12	19	13	16

9.4.5 Project Managers' and Experts' Agreement of Factors for Improving On-site Productivity

By adopting concurrent validation technique (see Cronbach, 1990), the ranking provided by PMs was compared to those from experts. In this case, the experts ranking of the factors for improving productivity was set as being rule of thumb that consider a absolutely true value. The ranking of the factors provided by experts were analysed using the same technique when analysing PMs' agreement of ranking of the factors for improving productivity. Kendall concordance coefficient from seven experts provided W = 0.35 with highly significance of level 0.000019 (see Table 9.9).

Validation of the on-site productivity improvement factors was carried out using the ranking of the factors by the PMs obtained previously were compared to 7 experts using Spearman Correlation Analysis. Table 9.10 provides an agreement of ranked importance of the factors by PMs (Xi) and experts (Yi). The agreement ranking of the factor between PMs and Experts indicate that the ten highest factors in each ranking are the same, albeit not in the same order.

The Spearman rank correlation test result suggested that those factors that ranked high in terms of importance by PMs were likely to be ranked high by Experts being indicated by a highly significant validation coefficient of 0.79. However, further examination of the results indicated that there were some factors which the two groups perceived differently e.g., 'work measurement' and 'incentives'. Project managers tend to consider that work measurement was more important than experts. Experts agreed that incentives were more important than project managers.

Other factors on which the two groups had different perceptions were 'sequence of work' and 'site communication'. Project managers rank 'sequence of work' second while experts rank it tenth. This perhaps indicates that PMs consider 'sequence of work' to be part of the knowledge required to facilitate efficient construction. It was considered less important by experts because they assumed that management teams should be able to handle these aspects of the work. However, project managers perceived that if the sequence of work was not well planned, reworks could be generated, therefore, they assigning more importance to this aspect.

Table 9.9 Priority Ranking of On-site Productivity Improvement Factors by Industrial Experts.

Code	Factors	Mean Rank	Priority Rank
F12	Methods of Construction	17.07	1
F23	Site Communication	15.57	2
F11	Engineering Design	16.86	3
F21	Planning and Scheduling	16.79	4
F26	Manpower Management	15.57	5
F33	Supervision Quality	15.50	6
F24	Material Management	15.36	7
F22	Site Layout	15.21	8
F25	Equipment Management	13.79	9
F13	Sequence of Works	12.64	10
F31	Site Safety	12.36	11
F47	Absenteeism	11.43	12
F43	Incentive	11.07	13
F36	Workers Participation	11.00	14
F14	Work Measurement	10.00	15
F41	Level of Pay	9.50	16
F42	Satisfaction	9.43	17
F46	Peer Relationship	9.43	17
F45	Foreman-Craftsmen Relationship	9.36	19
F34	Job Security	8.21	20
F44	Fringe Benefit	7.07	21
F32	Physical Environment	6.86	22
F35	Job Training	5.93	23

Cases	W	chi-square	D.F	Significance
7	0.3478	53.5553	22	.000019

Table 9.10 Agreement between PMs and Experts for On-site Productivity Improvement Factors

Code	Factors	Xi	Yi	di = Xi - Yi	di^2
F11	Engineering Design	5	3	2	4
F12	Methods of Construction	3	1	2	4
F13	Sequence of Works	2	10	-8	64
F14	Work Measurement	6	15	-9	81
F21	Planning and Scheduling	1	4	-3	9
F22	Site Layout	9	8	1	1
F23	Site Communication	10	2	8	64
F24	Material Management	7	7	0	0
F25	Equipment Management	11	9	2	4
F26	Manpower Management	8	5	3	9
F31	Site Safety	12	11	1	1
F32	Physical Environment	20	22	-2	4
F33	Supervision Quality	4	6	-2	4
F34	Job Security	18	20	-2	4
F35	Job Training	21	23	-2	4
F36	Workers Participation	19	14	5	25
F41	Level of Pay	17	16	1	1
F42	Satisfaction	15	17	-2	4
F43	Incentive	22	13	9	81
F44	Fringe Benefit	23	21	2	4
F45	Foreman-Craftsmen Relationship	13	19	-6	36
F46	Peer Relationship	14	17	-3	9
F47	Absenteeism	16	12	4	16
				Σdi^2	433

Note: Xi and Yi represent Project Managers and Experts respectively.

$r_s = 1 - 6\sum di^2 / n(n^2 - 1) = 1 - 6 * 433 / 23\,(529 - 1) = 0.786$

Test for rank correlation from SPSS provides highly significant of 0.0000.

Site communication was ranked 2nd by the experts, and 10th by the managers. This large difference may be caused by development in the communication system being applied at the past and the present. On one hand, as what had been experienced by experts, communication was given placed paramount because of the scope of work that have to be handled mainly by the main contractors themselves. On the other hand, subcontracting jobs have been common practices that can reduced main contractors responsibility communication, i.e. explanation of procedure or process of construction to the workers. Sub contractors and specialists were being employed in handling the difficult jobs. These have perhaps enlighten the main contractors in site communication at present construction sites.

Perception of the importance 'foremen-craftsmen relationship' between the two groups were also differed. It was ranked 13th and 19th by the project managers and experts respectively. This indicates that the importance of work relationship between foremen and craftsmen has increased its importance and hence can work as a solid team. Furthermore, increased industrial relation problems as witnessed recently in other sectors of industry (in Indonesia) may influence project managers, to pay more attention to this relationship.

Project managers ranked 'worker participation' 19th, whilst experts ranked it 14th. This perhaps indicates that the participation of workers in decision making by means of contributing ideas in planning, or methods in performing construction activities was more paramount in the past. Whilst at the present, project managers tend to delegate this matter to the sub-contractors or their foremen.

9.6 Summary

The analysis of ranking by experts, and project managers in reputable construction firms has shown that factors influencing on-site productivity can be prioritised. An examination of the resulting agreement in ordering of the factors shows that those high on the priority list are generally readily identifiable from project information and directly quantifiable by the contractors' project manager. Further, their impact upon on-site productivity can be assessed explicitly.

The ten most predominant factors affecting on on-site productivity are: methods of construction, planning and scheduling, engineering design, supervision quality, sequence of work, site communication, manpower management, material management, and site layout.

Factors appearing low on the priority list are those whose effect upon on-site productivity are not readily assessed. Also their influence may not be within the direct control of the site management. It is likely that project managers could have developed "rules of thumb" for dealing with the effect of such factors upon on-site productivity rather than any form of detailed analysis.

Although factors are clearly identified from project information on high rise construction in Indonesia, it is difficult to explicitly evaluate their impact in terms of resource utilisation.

The analysis of ranking by project managers of reputable construction firms has shown that factors affecting site productivity can also impact on resource utilisation, and, these can both be prioritised. An examination of the resulting agreement in ordering of the factors shows that those high on the priority list are generally readily identifiable from project information and directly quantifiable by the contractors' project manager. Further, their impact on on-site productivity can be assessed explicitly.

The five most predominant factors affecting the four resource utilisation measures, in descending order are:

1. Time utilisation: 'methods of construction', 'planning and scheduling', 'site layout', 'material management', and 'sequence of work'.
2. Material utilisation: 'material management', 'supervision quality', 'planning and scheduling', 'methods of construction', and 'engineering design'.
3. Labour utilisation: 'planning and scheduling', 'manpower management', 'work measurement', 'supervision quality', and 'methods of construction'.
4. Plant utilisation: 'Equipment management', 'planning and scheduling', 'site layout', 'sequence of works', and 'engineering design'.

CHAPTER 10

CHAPTER 10
DEVELOPMENT OF A
CONSTRUCTION PRODUCTIVITY AUDIT SYSTEM (CONPAS)
FOR INDONESIA - THE DYNAMICS OF THE SYSTEM

10.1 Introduction

Knowledge on construction productivity has often been disseminated in technical reports, journal articles and through seminars. These traditional ways for university researchers to contribute knowledge gained from research have been reasonably successful in some cases. A manager who desires to use this knowledge in order to evaluate a construction site must read through volumes of technical reports to get to the recommendations or must find journal articles which may not be in the company home office library, or much less at the job site.

This chapter reports the development of an interactive computer based productivity auditor which can assist project managers monitor and improve their efficiency in managing the construction process. Tools for developing CONPAS are briefly described, followed by explanation of knowledge elicitation and system design of CONPAS in which the dynamics such as the development framework, modular system interface, output, technique, and application are presented. CONPAS is then tested using three case studies.

10.2 The Development Tools

There are currently five ways to put a knowledge-based system into a computer: (1) Expert system shell; (2) Expert system environment; (3) AI language; (4) Conventional package; (5) Conventional language.

Expert system shells, which are packages designed to support the development of KBS usually provide one specific way of representing knowledge. Since the inference engine is programmed in a KBS shell, a system developer's main work is to create a knowledge base.

Expert System shells are easy to use, especially for developing prototype systems but they also have some limitations. There are currently over a dozen shells available in the market including DECIDING FACTOR, INSIGHT 2+, M-1, EXSYS, PC PLUS, SAVIOR, CRYSTAL, EXPERT EASE, ROSIE, GURU, ES/P ADVISOR, LEONARDO, GOLD WORK, VP-EXPERT, AND NEXPERT. Since these shells can be easier and quicker to use than either programming language or others development tools, they are more popular for developing knowledge based systems (Mohan, 1990). A survey by Touche Ross (1992) in co-operation with the DTI in UK confirmed the domination of implementation shells in the business environment by as much as 43%. In the UK, CRYSTAL is reportedly to be the most widely used shell: other popular shells are LEONARDO and Xi. In the USA, some popular shells used for both commercial and research in construction are as EXSYS (Hanna et.al.,1992; Mohan, 1990) and VP-EXPERT. The latter has been adopted by the Construction Industry Institute as a research and training tool because it is inexpensive (Bell and Elzarka, 1992). In developing this audit system for improving on-site productivity, VP-Expert shell was selected because it was available and could provide sufficient capacity to install all rules needed in the system and has the backward chaining inference mechanism, the same strategy used in developing the model.

The hardware selected for developing CONPAS was IBM PC and compatible machines with two disk drives. IBM PC group computers were selected mainly because the shell VP-EXPERT was developed for use on those computers. Also, the majority of the site managers forming the target group for the system use IBM and compatible machines. VP-EXPERT is a DOS environment shell and can be interfaced with other software e.g. Lotus, DBase III Plus, in the same computing environment, which can be very handy for generating weights for factors in multiple criteria decision making problems (Bell and Elzarka, 1992). The reports needed to be generated by a KBS can also utilise text editor or word processing (e.g. Word Star, Word Perfect or Word for Window) which is available for IBM PC, and installed in almost every construction company office.

10.3 Knowledge Elicitation

The knowledge acquisition procedure for CONPAS followed the tradition in KBS literature (Hanna, 19924; Karen & Karen, 1989):

(1) Knowledge familiarisation. This is the first stage in the development of a knowledge based system. The intention at this stage is to familiarise with the knowledge base which will be used as a basis to elicit 'deep' knowledge from experts. It includes extracting knowledge from major articles and text from the problem domain which is the focus of the knowledge base. From this first process, possible option of the models of solution can be developed and compared with the perceived real world problem. The author first extracted productivity factors from previous construction site productivity studies (Olomolaiye and Ogunlana, 1989b; Maloney, 1991; Liu, 1991). A comparative review of three frameworks for productivity improvement had been conducted in Kaming (1992) and based on a critical evaluation, an on-site productivity improvement model presented in Figure 10.1 was developed.

(2) Knowledge elicitation. The model in Figure 10.1 was converted into a repertory grid with a structure like an interview sheet (Appendix D Section 7) combining factors (element) and level of importance of each factors completed during structured interviews with construction experts. To derive importance weight for each factor, the parameters which may influence the importance of each factor were assessed. For instance in assessing equipment management in high rise construction, the expert was requested first to identify the equipment for such a project, e.g. tower crane, concrete pump, hoist, and possibly batching plant. The second step requested the expert to assess how efficiently the equipment usage integrated with project schedule; including maintenance aspects. The third assessment was integration of labour and equipment utilisation on the site.

(3) Knowledge formulation. The overall knowledge base extracted from the second stage was then structured as presented in Figure 10.2 for the case of module one: Identification of Productivity Problem, and Tables 10.1, 10.2, 10.3 and 10.4 for the modules of Method and Technology, Site Management, Working Environment, and Human Factors respectively.

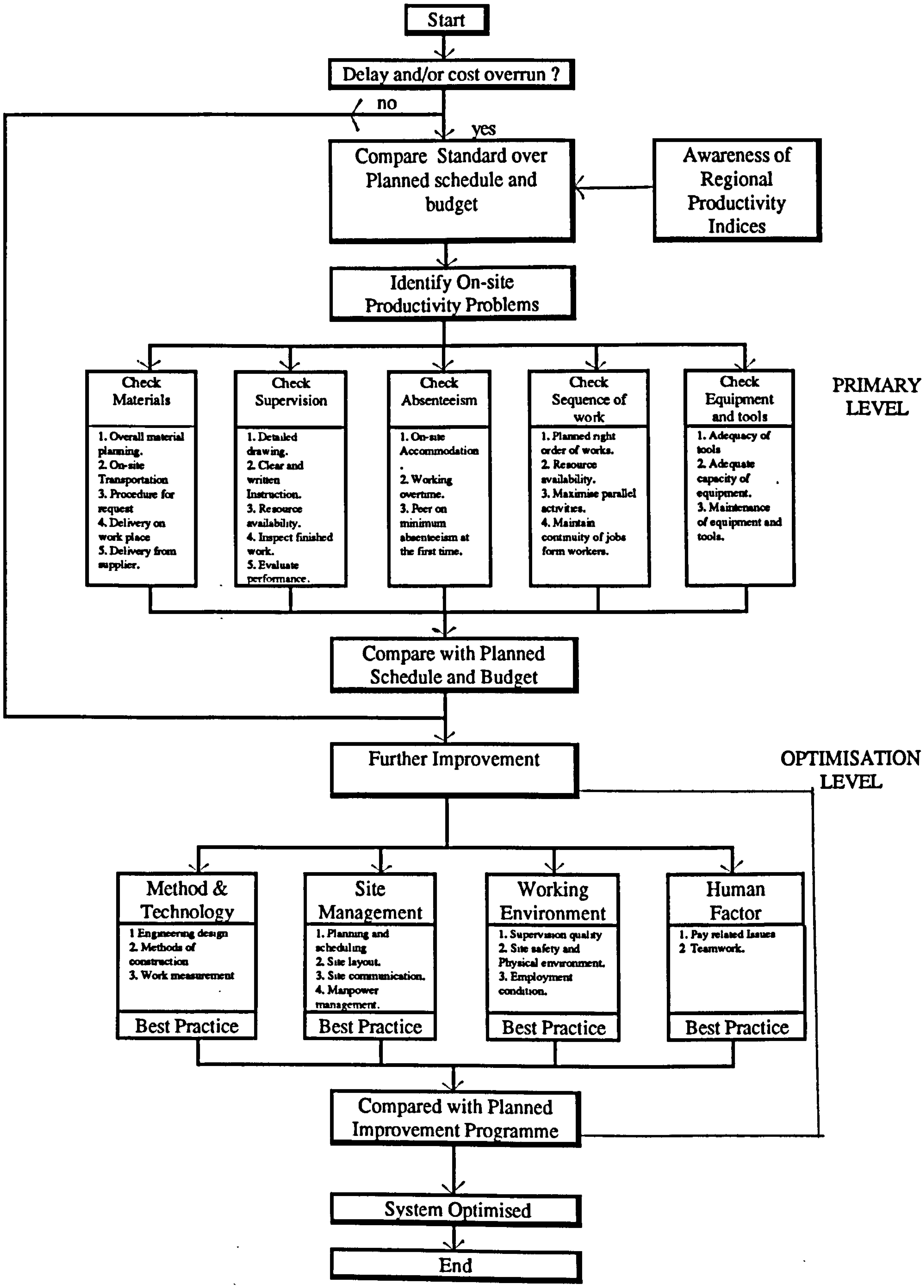

Figure 10.1 Framework of the Construction Productivity Audit System (CONPAS).

Table 10. 1. Decision Matrix for Best Practices - Method and Technology.

Category	Factors	Parameters	Best practices
Methods and Technology	1 Engineering Design	1.1 Standardisation or Uniformity. 1.2 Simplicity of Details. 1.3 Correctness of Measurement. 1.4 Ease for Fabrication. 1.5 Availability of Material on Market	1.1 Ensure adequate design / engineering lead time. 1.2 Do not allow site construction activities to get ahead of the design/engineering and supply functions. 1.3 Where possible, have experienced site field foremen/engineers review engineering concepts and construction drawings prior to initiating the works. 1.4 Ensure that "approved for construction" drawings and schedules contain all the necessary erection information and that such information is readily available and simple to extract. 1.5 Ensure that labour force, the first line supervision, the inspectors and quality assurance engineers are properly introduced to and trained in the project specific specifications, thus setting clear definition of the required standards and encouraging a commonalty of purpose.
	2 Method of Construction	2.1 Minimum Unit Cost. 2.2 Faster than the Past. 2.3 Increased Volume. 2.4 Availability of Experience. 2.5 Availability of Equipment to Support the Method.	2.1 Construction methods should be selected to provide the most productive result based on a cost effective analysis of time, cost, safety, practicability, quality achievable and the availability and utilisation of resources. Five principles are: 2.2 The contractor must be given the opportunity to input into the design mechanism to provide expert advice on the most simple and effective construction method. 2.3 All critical construction methods should be written down into formal statements of intent and approved. 2.4 Changes in methods and procedures should be implemented with the full co-operation of workforce and this aspect requires effective communication between all parties on-site.
	3. Work Measurement	3.1. Time /duration records. 3.2. Material Cost records. 3.3. Labour Cost Records 3.4. Equipment Cost records. 3.5. Perform Work study	3.1 Perform work study using a standard system.

Table 10.2 Decision Matrix of Best Practices - Site Management.

Category	Factors	Parameters	Best Practices
Site Management	1. Planning and Scheduling	1.1 Site management should carry out subject based detail plan: construction scheduling plan, logistic plan, manpower plan, procurement plan, financial plan, evaluation plan.	1.1 A computerised planning system is beneficial but demands that detailed information is available at the very beginning of a project and that such information is regularly updated and a format that is readily understood by supervision. Progress assessment must be accurate and regularly monitored.
		1.2 Updating plan and schedule.	1.2 Perform time based/detailed plan for activities in critical path.
		1.3 Time based plan: monthly, weekly, and/or daily plan.	1.3 Detailed schedules must be available for engineering input and material deliveries.
			1.4 Detailed programmes should be issued weekly to the site supervision and progress made consistently monitored.
			1.5 Work scope installation should not commence until there is an adequate level of materials and drawings available to maintain production.
	2. Site Layout	2.1 Existing services: sewer drain, water, electricity, gas, and telephone, accommodation for site staff, sub-contractors, others.	2.1 Sign and notice: name board, direction board, public relation board, warning notice, administration area & visitor notices, parking sign, bulk stacking material area, reporting notice, position & depth existing services, safety switches, fire alarm, hard hat area notices, unsure plant or machine notice.
		2.2 Site security: fences, gantries, shoring to adjacent building.	2.2 Provide existing services : sewer drain, water, electricity, gas, and telephone.
		2.3 Access & exist: number, size, cross over, and ramps.	2.3 Hoarding: secure site, fences, gantries, shoring to adjacent building.
		2.4 Plant, and equipment position: static and movable.	2.4 Access & exist: number, size, cross over, and ramps.
		2.5 Stores, storage facilities, compound: handstand for bulk material, compounds, stores shed, curing shed, cement shed.	2.5 Administration and other accommodation: for site staff, subcontractors, others.
			2.6 Workshops: fitter shops & work area, joinery shop & machinery, bar bending area, and concrete mix area.

Table 10.2 (Continued) Decision Matrix of Best Practices - Site Management.

Category	Factors	Parameters	Best Practices
Site Management	3. Site Communication	3.1 Standard sheet for on-site communication practice.	3.1.1 Material received sheets. 3.1.2 Material/plant transfer sheets. 3.1.3 Time sheet 3.1.4 Wage sheet 3.1.5 Bonus sheet
		3.2 Progress report	3.2.1 Presentation of construction plan by site manager to foremen and trades before work is commenced. 3.2.2 Programme report 3.2.3 progress report 3.2.4 Valuation of work done. 3.2.5 Having a direct hot line to the off-site design office or managing contractors thus encouraging prompt decisions. 3.2.6 Investigate complaint & suggestion from employees.
		3.3 Claim management	3.3.1 Standard contract forms 3.3.2 Variation order. 3.3.3 Subcontractor claims documentation.
		3.4 Communication for aspect of safety and health	3.4.1 Notification request to Governmental Agencies for inspection. 3.4.2 Detail of disciplinary warning. 3.4.3 Notification request for health & safety 3.4.4 Accident report & statistics.
	4. Manpower Management	4.1 Avoid labour absenteeism by provision of on-site/ accommodation.	4.1 Introduce practical skill tests for all trades prior to employment.
		4.2 Develop multi-skilled tradesmen from apprenticeship stage.	4.2 Introduce a system of regular individual assessment covering quality and quantity of output.
		4.3 Span of control for each foreman (Foreman and craftsmen ration 1 : 10)	4.3 Encourage trade flexibility through training in new methods and practices followed by the allocation of suitable work tasks.
		4.4 Keep balancing gang against unit work.	
		4.5 Keep balancing gang against plant.	4.4 Re-training in new methods, skills and procedures to supplement existing skill levels and experience.
		4.6 Promote foremen training programme on management aspect	

Table 10.3. Decision Matrix of Best Practices - Working Environment.

Category	Factors	Parameters	Best Practices
Working Environment	1. Safety and Physical Environment.	1.1.1 Safety programme & policies.	1.1.1 Maintain copies of appropriate publication concern with safety & programme.
		1.1.2 Representative for managing safety and health.	1.1.2 Co-operation with the subcontractors on overall job site safety programme.
		1.1.3 Provision of safety device.	1.1.3 Appoint full authorised representative for preventing accident.
		1.14 First aids for accident	1.1.4 Indoctrination on safety to all new employees.
		1.1.5 Preventive management for accident.	1.1.5 Provide periodic training. 1.1.6 Prompt investigation of all accidents.
			1.1.7 Plan work to protect against personnel injury. 1.1.8 Site inspection & correction if needed.
		1.2.1 Physical environment	1.2.1 Position of messing and toilet facilities as close to work place as possible. 1.2.2 Provision of shelter for workers to protect from direct hot weather on jobs. 1.2.3 Improve ground condition. 1.2.4 Anticipate work condition for raining. 1.2.5 Reduce excessive dust and noise.
	2. Supervision Quality	2.1 Creativity 2.2 Decision making ability 2.3 Taking Subordinate into account in decision making. 2.4 planning work.	2.1 Keeping up to date with register diaries and reports. Ensure the quality control keeps fully up to date with production, so that prompt action can be taken when rejected work is established.
		2.5 concern of site safety 2.6 Lay out work 2.7 Responsible for work 2.8 Ability to direct workers and give instructions precisely.	2.2 Carry out planned and comprehensive audits on potential sub-contractors before entering into contract. 2.3 Supervisors arrival and departure times. 2.4 Supervisors wear safety helmet (device) when touring work place. 3.3 Politeness of supervisors.
		2.9 Ability to motivate workers	2.5 Prompt attention to individual problems. 2.6 Actions on individual problems for promise given.
		2.10 Willingness to accept suggestion	2.7 Chase up detail and queries quickly when requested.
		2.11 Proud of work and crew	2.8 Maintenance of tidy site to reduce hazards.
		2.12 Confident 2.13 evenly tempered	2.9 Observance of working rules agreement. 2.10 Observance of safety code. 2.11 Delegate to and trust subordinate.

Table 10.3 (Continued) Decision Matrix of Best Practices - Working Environment.

Category	Factors	Parameter	Best Practices
	3. Employment Condition	3.1 Job security.	3.1.1 Establishment of security guarantee. 3.1.2 Worker acceptance of present condition. 3.1.3 Worker acceptance of productivity improvement programme. 3.1.4 Policies of dismissing excessive inexcusable absence of worker.
		3.2 On site training for workers. (Learn while doing.)	3.2 New workers training for particular task and objective of the project.
		3.3 Relating performance and pay.	3.3 New employees, but has working experience is provided goal of project and peered on teamwork.
		3.4 Skill assessment for individual worker.	3.4 Existing workers: Enhancing new technique by training, and pursue new technique for improving productivity.
		3.5 Consideration of worker participation in planning.	3.5 Site management considers and recognises workers' suggestion. 3.6 Establishment of clear team goal. 3.7 Workers understand their roles both as individuals and as part of a team.
		3.6 Treating worker individually.	3.8 Foremen and trades involvement in construction planning. 3.9 Subcontractors involvement in the special work plan.

Table 10.4 Decision Matrix of Best Practices - Human Factor

Category	Factors	Parameter	Best Practices
Human Factor	1. Pay Related Issues	1 Promotion and upgrading scheme for workers.	1.1 Individual salary scheme. 1.2 Remuneration evaluation for a certain period. 1.3 Remuneration adjustment caused by inflation. 1.4 Remuneration adjustment caused by Government regulation. 1.5 Upgrading employee status scheme. 1.6 Performance assessed: monthly, fortnightly, weekly, and daily.
		2 Acknowledgement of management to workers' performance.	2.1 Reward worker for good performance. Reward types: money, gifts, and/or time off while paid. 2.2 Do not give bonus "automatically" - financial incentives must be earned. 2.3 Financial incentives are more effective when applied to small teams of workers and displaying team performance can also encourage productivity improvements. 2.4 When bonuses are used, the work done must be easily measurable and accurately measured. 2.5 Record of individual workers' performance 2.6 Financial incentive plan, e.g. piece work, standard hour, or measure day work plan. 2.7 Comparison of standard unit output and actual output. 2.8 Comparison of standard cost with actual cost. 2.9 Worker performance appraisal by supervisor. 2.10 Acknowledgement of employee capability by providing certificate. 2.11 Accident insurance. (JAMSOTEK) 2.12 Worker welfare: transportation and new years allowance.
	2 Team Work	2.1 Regular meeting among management, foremen, and trades. 2.2 Job related information provided by management to workers 2.3 Work rules and procedures accessible by workers.	2.1 Provide necessary information for worker to do the task. 2.2 Provide necessary equipment, tools and material. 2.3 Communication work rules and procedures. 2.4 Select a field supervisor that would get along with the job. 2.5 Use weekly scheduling meeting to promote understanding, co-operation, and trust of each other job among foremen.
		2.4 Cohesiveness among craftsmen. 2.5 Cohesiveness among foremen.	2.6 Attempt to eliminate confrontation between foremen. 2.7 Attempt to eliminate confrontation between craftsmen 2.8 Initiate educational efforts to promote relationship.

10.4 System Design

The most common paradigm of knowledge representation is the production rule system. The knowledge in a production rule system is represented as a rule that has the general form: IF - THEN (antecedent - consequence), or an extension of IF - THEN - ELSE rule. CONPAS adopted this knowledge representation paradigm since it is appropriate and compatible with the construction productivity improvement model.

Rules are combined in rule clusters or blocks that constitute a branch of a decision tree. If the antecedent is satisfied, then the rule is 'fired' and the indicated action taken, which is followed by either the examination of another rule or termination of a rule block. Termination leads to the selection of conclusions or recommendations by the inference engine.

Other methods for representing knowledge are frame-based system, semantic network, and mathematical logic. These methods were not selected for CONPAS simply because VP-EXPERT has the production rule paradigm, and not because they are inferior production rules in any way. Further detailed information concerning knowledge representation is provided in literature (Adeli, 1988; Allwood, 1989).

10.4.1 The Development Framework

In order to represent the knowledge base in a computer system, it is compulsory to develop a framework. Figure 10.1 exhibits the development framework that decomposed into five main on-site productivity problems identified in Chapters 5, 6, 7, 8 and 9, with one module for productivity problems diagnosis at primary level, and other four modules for investigating productivity improvement at optimisation level. Each module has several factors and each factor decompose into several parameters. The purpose of the decomposition is for ease of representation of a huge decision tree.

10.4.2 Modular System Interface

The program consists of four modules that can be independently run by the user. Each module can be selected through an initial window when the user first starts the program.

The selected productivity problems and on site productivity improvement factors and their corresponding parameters that affect on-site productivity, once obtained, are transformed into the decomposed frameworks as in Figure 10.2. For ease of presentation, the knowledge base is presented in Tables 10.1, 10.2, 10.3 and 10.4). The system asks questions on these areas to arrive at a summary of conditions on the site.

10.4.3 Design of Output

The overall output system design is shown in Figure 10.3. The system provides a report generated at the final run with severity index ranging from null (no problems) to 1 (very severe problem) in each module. Thus in the final report of each module, result and recommendation are generated. For example, if after running module one, the system concludes that the overall severity index of productivity problems of the project is 0.685 with material management problem severity index 0.837, rework 0.688, supervision delay 0.148, work interference 0.84, changing of craftsmen 0.77, changing of foremen 0.144, overcrowding 0.426, absenteeism 0.608, working overtime 0.426, and tool/equipment management problem 0.684 (see Table 10.5), the system collects each result of problem investigation and keeps them in a temporary file. The system then recognises the command and generates reports as shown in Table 10.5 At the final run of each module, the system provides consultation for resolving the problems or on how to improve productivity in terms of best practices (modules 2 to 5).

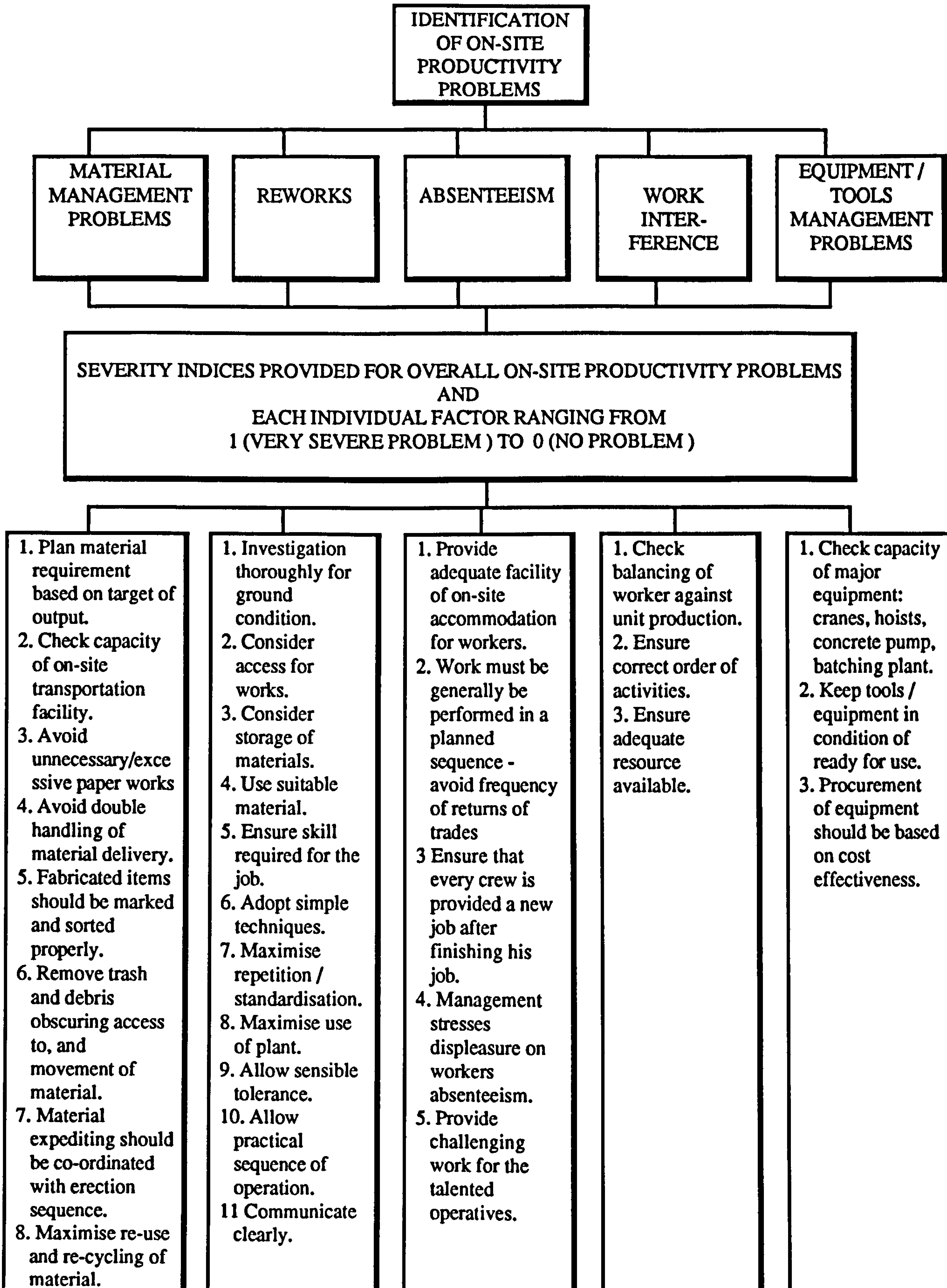

Figure 10.2. The Development Framework for Module One - Identification of On-site Productivity Problems.

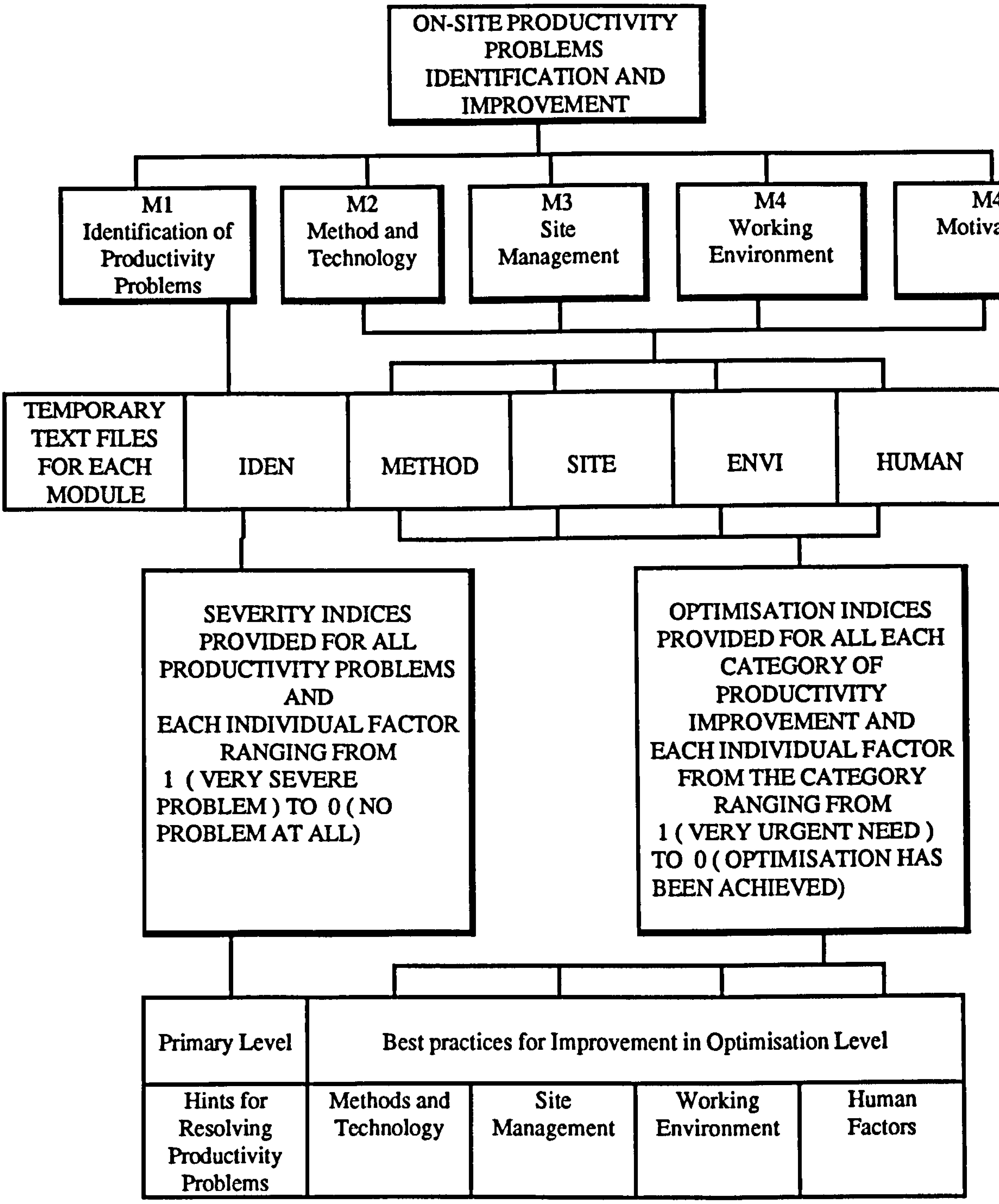

Figure 10. 3. Framework of the System for Report Generated of CONPAS.

Table 10.5 An Illustrative Summary of Report Generated by the System's Module 1

SUMMARY	
The overall index of productivity problem is	0.685
Material management problem index is	0.837
Rework problem index is	0.688
Supervision delay index is	0.148
Worker interference problem index is	0.840
Changing of craftsmen problem index is	0.770
Changing of foremen problem index is	0.144
Over crowding problem index is	0.426
Absenteeism problem index is	0.608
Working overtime problem index is	0.426
Equipment/tools management problem index is	0.684

Note: The severity of the problem indicated by indices ranging from 1 (very severe problem) to 0 (no problem at all).

10.4.4 Multiple Criteria Weighting Technique

The technique used in the implementation of CONPAS is based on the multiple attribute utility theory. To weigh the factors that affect a category, an ordinal scale: very important, important, and less important was employed. These weightings were obtained from domain project managers and experts in the field and converted into severity indices to facilitate application in VP-EXPERT.

The first module, Identification of Productivity Problems, consists of ten factors assigned by experts as :

0.93 for material management problems,

0.86 for reworks,

0.74 for supervision delay,

0.80 for absenteeism,

0.71 for working overtime,

0.80 for work interferences,

0.77 for changing of craftsmen,

0.72 for changing of foremen,

0.71 for over crowding,

0.76 for tools/equipment management problems.

The outcome values for this audit system range from 0 to 1. However, in order to achieve consistency with the weighting criteria an ordinal scaling would need to be assigned. The values assigned for this purpose are: 5 for 'high frequency', 3 for 'medium frequency', and 1 'low frequency'.

These values were also needed for arithmetic manipulation to use the 'mathematics function' on VP-EXPERT. From this information, a standard scale for the system was established. The largest rating that a user can obtain by answering the question positively is 0.685, i.e. the outcome from multiplication of the largest outcome value with the weighting criteria obtained from the regression analysis of all variables as shown in the equation below:

$$\text{Overall Index (OI)} = \sum In^*Pn / \sum In \quad \text{.........................(10.1)}$$

From these values a scale is constructed for installing the rules in the "mathematics function" in VP-EXPERT.

10.4.5 How the System is Used

In developing the knowledge based system, we envisage a site manager/engineer who is concerned about productivity improvement but who does not know how to assess his/her site and what to do to improve it. Liu's study has shown that the majority of young managers in developing countries are ill-prepared for this task. CONPAS, if installed on site, provides ready access to information on how to assess site performance and carry out necessary improvement programs.

The manager needs to input data of the construction site into the system. The system provides an assessment of site performance and generates guidelines for improving performance. It will be a good training tool for the manager as attention is focused on those areas that need his/her intervention. The user of the system is asked questions that require simple answers such as available/not available, done/not done, yes/no. Unlike the approach used in Liu's system, the user does not have to make qualitative judgement such as very good, good, poor, etc. This reduces subjectivity on the part of novices and enhances the expertise in the system as inference is left to the system.

10.5 Validation

The process of validation is defined as 'the checking of the appropriateness of a model to help tackle real world problems, as seen from the point of those involved in the model's creation and use' (O'Keefe. et.al 1987) One special and well-developed area of validation is that of verification, which is a process of testing computer programmes to see that they perform as expected. Verification is not concerned with the appropriateness of relations that make up the model, only with whether the translation of the relationship into a computer representation has been done correctly. In contradistinction to validation, it is theoretically possible to test that the representation is 'correct'. In other words, verification is establishing that what has been described is rightly represented on the computer.

In general, validation of a computerised system considers five basic criteria (see Allwood, 1989; and O'Keefe, 1987):

1. Consistency: The ability to produce similar answers to similar questions. If constructed properly, the system should be consistent.
2. Completeness: The ability to tackle problems successfully within its domain. This ability should increase as the knowledge base of the Expert System increases.
3. Correctness: The ability to make correct decisions. This is a difficult measure since it is necessary to define what is correct. Therefore subjective judgements from expert are needed to confirm the correctness of knowledge bases.
4. Precision: For cases involving decision under risk (with probability). Precision is the ability to establish a certainty factor (or probabilities of occurrence) as close to reality as possible. Again, the difficulty here is a lack of standards to compare against.
5. Useability: The ability of the system to deliver consultation as designed.

Since many Expert Systems began as research prototypes, validation has often been conducted to qualitatively measure system performance. There are seven common qualitative approaches to validation some of which have been used to validate expert system performance:

1. Face validation: This is a useful preliminary approach to validation. Project team members, potential expert system users, and people knowledgeable about the

application domain subjectively compare system performance against human expert performance.

2. Predictive validation: Predictive validation requires using historic test cases and either (i) known results or (ii) measures human expert performance on those cases. An Expert System is driven by past input data from test cases, and its results are compared with corresponding results.
3. *Turing* test: This validates Expert System against human expert by evaluating human expert performance and system performance without knowing the subject performance's identity. Assessments of system performance can then be compared with assessments of human performance.
4. Field test: This places prototype Expert System in the field, and then seek to perceive performance errors as they occur. Field testing is possible only in non-critical applications, where user can assess the correctness of Expert System performance.
5. Subsystem validation: This requires that Expert System be decomposed to subsystem, enabling the performance of each subsystem to be observed under input data. In this approach, subsystems are validated one at a time as they are developed.
6. Sensitivity analysis: This is performed by systematically changing Expert System input variable values and parameters over some range of interest and observing the effect upon system performance. Sensitivity analysis is specially useful where few or not test cases are available. It is also highly appropriate for systems using uncertainty measures and requiring user to provide judgement for premise uncertainty.
7. Visual interaction: This provides visual animation of Expert System working and allows experts to interact, altering parameters as desired. This validation approach could apply to Expert System, particularly with the appearance of geographical interfaces to Expert Systems.

10.5.1 Reliability Analysis

How reliable are the eleven factors applied to measure severity of the productivity problem? In order to answer this question, the scale used to assess the severity of the productivity problem was tested using reliability analysis. Twenty nine construction sites were rated by their respective project managers on eleven factor / items (reliability analysis in SPSS represents factors as items) shown in Table 10.6. For each item, a score of 4 was assigned if it was considered of high importance, 3 for important, 2 little importance, 1 not important. Next was to assign each item in terms of their frequency of occurrence on the respective sites on a three point scale from high (3) to low (1). Severity was the product of importance and frequency. A severity index was established using the equation:

$$\text{Severity Index} = \Sigma\,(I * F\,)\,/\,N \qquad \text{.................................} 10.2$$

where I represent importance of the item, F frequency of occurrence and N the Number of cases. The higher the index, the higher the severity of the productivity problem. For the purpose of reliability analysis, the scale of severity indices ranges from 1 to 12.

Table 10.6 Univariate Descriptive Statistics for Factors/Items Influencing On-site Productivity.

Items	Productivity	Mean	Std Dev
1	Lack of material	6.24	2.85
2	Lack of tools	4.07	2.24
3	Equipment breakdown	4.68	2.84
4	Repeat work.	5.55	3.37
5	Changing craftsmen.	5.48	2.94
6	Interference.	6.37	3.27
7	Absenteeism.	6.24	3.42
8	Supervision delay.	4.20	2.60
9	Overcrowding.	4.65	2.58
10	Changing foreman	3.83	2.00
11	Working overtime	5.28	2.05

When a scale is summarised, it is possible to examine the characteristics of the individual items, the characteristics of the overall scale, and the relationship between the individual item and entire scale. Table 10.6 contains descriptive statistics for the individual items. The average score on the severity scale ranges from 6.38 for item 6 to 3.83 for item 10. Item 7 has the largest standard deviation of 3.42. Table 10.7 illustrates the correlation between the severity of productivity problems. Additional statistics for the scale as a whole are as shown in Tables 10.8 and 10.9.

Table 10.7 Correlation Matrix of On-site Productivity Problems

Item	1	2	3	4	5	6	7	8	9	10	11
1	1.00										
2	0.08	1.00									
3	0.29	0.08	1.00								
4	0.27	0.12	0.15	1.00							
5	0.23	0.02	0.27	0.19	1.00						
6	0.59	-0.06	0.48	0.35	0.44	1.00					
7	0.41	-0.22	0.38	0.17	0.13	0.58	1.00				
8	0.05	0.17	0.05	0.05	0.16	-0.03	0.09	1.00			
9	0.24	0.12	0.11	0.22	0.15	-0.01	0.11	0.40	1.00		
10	0.05	0.01	0.20	0.13	0.36	0.09	0.14	0.08	0.34	1.00	
11	0.32	0.24	0.28	0.42	0.47	0.42	0.36	0.08	0.23	0.26	1.00

Table 10.8 Scale Statistics

Statistics for Scale	Mean	Variance	Std Dev	N of Variables
Item Means	57.62	260.39	16.14	11

Table 10.9 Summary Statistics for Items

	Mean	Minimum	Maximum	Range	Max/Min	Variance
Item Means	5.24	3.83	6.55	2.72	1.71	1.01
Item Variances	7.74	4.00	11.69	7.68	2.92	7.42
Inter-Item Correlation	0.20	-0.22	0.59	0.81	-2.67	0.03

10.5.1.1 Relationship Between the Scales and Items

Let's take a look at the relationship between the individual items and composite score (see Table 10.10). For each item, the first column of the table shows what the average score for the scale would be if the item were excluded from the scale. For example, we know from Table 10.8 that the average score for the scale is 57.62. If item 1 were eliminated from the scale, the average score would be 51.38. This is computed by simply subtracting the average score for the item from the scale mean. In this case, 57.62 - 6.24 = 51.38. The next column is the scale variance if the item were eliminated. The column labelled Corrected Item-Total Correlation is the Pearson correlation coefficient between the score on the individual item and the sum of the score on the remaining items. For example, the correlation between the score on item 8 and the sum of scores of items 1 through 11 is only 0.18. This indicates that there is not much of a relationship between the 8th item and other items. On the other hand, item 11 has a significant correlation, 0.61, with other items.

Another way to look at the relationship between an individual item and rest of the scale is to try to predict severity of productivity problems on the item based on the scores obtained on other items. We can do this by calculating a multiple regression equation with an item of interest as the dependent variable and all of the other items as independent variables. The multiple R^2 from this regression equation is displayed for each of the items in the column labelled Squared Multiple Correlation. We can see that almost 66% of observed variability in the response to item 6 can be explained by the other items. As expected, items 8 and 10 are poorly predicted from the other items. Their multiple R^2 are only 0.24 and 0,22 respectively.

Table 10.10 Item-total Summary Statistics.

Item	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item - Total Correlation	Squared Multiple Correlation	Alpha if item Deleted
1	51.38	209.96	0.51	0.44	0.70
2	53.55	249.90	0.08	0.25	0.75
3	52.93	215.00	0.45	0.29	0.71
4	51.07	211.71	0.38	0.26	0.72
5	52.14	213.62	0.44	0.45	0.71
6	51.24	195.40	0.59	0.68	0.69
7	51.38	206.96	0.42	0.52	0.72
8	53.41	238.89	0.18	0.24	0.75
9	52.97	228.82	0.32	0.33	0.73
10	53.79	238.96	0.28	0.22	0.73
11	52.34	219.38	0.61	0.48	0.70

10.5.1.2 Reliability Coefficient

By looking at the statistics shown above, we have learned about our scale and individual items of which it is composed. However, we are yet to come up with an index of how reliable the scale is. One of the most commonly used reliability coefficient is Cronbach's alpha. The alpha is based on the 'internal consistency' of a test by means of using average correlation of items within a test, if the items are standardised to a standard deviation of 1; or on the average covariance among items on a scale, if the items are not standardised. We assume that the items on a scale are positively correlated with each other because they are measuring, to a certain extent, a common entity. In this case, we do expect to see a positive relationship between this test and other similar tests.

Cronbach's alpha has several interpretations. It can be viewed as the correlation between this test or scale and all other possible tests or scales containing the same number of items, which could be constructed from hypothesis universe of items that measure the characteristics of interest. In measuring severity of productivity problem, for example, the eleven questions actually selected for inclusion can be viewed as a sample from a universe of many possible items. There could be other problems not in the list of the items which could happen on job site, for instance, items related to workers' motivation or skill. Cronbach's alpha tells us how much correlation we expect between our scale and all possible eleven item scale measuring the same thing.

Since alpha can be interpreted as a correlation coefficient, it ranges in value from 0 to 1. (Negative alpha values can occur when items are not positively correlated among themselves and the reliability model is violated.)

Cronbach's alpha for diagnosing severity of productivity problem generated by SPSS showing that the value 0.74 is reasonable to indicate that our scale is quite reliable. The other entry in the output labelled standardised item alpha = 0.738, is the alpha value that would be obtained if all the items were standardised to have a variance of 1. Since the items on our scale have fairly comparable variance, there is little difference between the two alpha's. If items on the scale have widely differing variances, the two alpha may differ substantially.

When we are examining individual items, as in Table 10.10, we may want to know how each of the items effects the reliability of the scale. This can be accomplished by calculating Cronbach's alpha when each of the items is removed from the scale. These alpha's are shown in the last column of Table 10.10. We can see that eliminating item two from measuring severity of the problem causes alpha to increase from 0.74 to 0.75. Because the change of this value is too small, it is reasonably to say that we would not expect any item to be eliminated in order to increase the reliability of the scale. Hence it is valid to state that the eleven variables are reliable as measurement of the productivity problems.

10.5.2 Validation of CONPAS

Unlike many conventional programmes, Expert Systems do not involve problems which can be assessed by clear answers like 'right' or 'wrong'. Therefore, validating expert system performance is not straight forward. Since the system was a quality problem that involve subjective judgement from the users, it was proposed to validate CONPAS by using predictive approach. The system was validated using data from 3 real life case studies, and results compared with the known corresponding results. The general characteristics of projects for the case study were as follows:

Project *A* - Office building, severe delay

Project *B* - University building, medium delay.

Project *C* - Commercial building, well managed, slight delay.

The overall severity of productivity problems as assessed by the respective project managers of the 3 cases were calculated as follows:

The delays of the projects were recorded as 18%, 11%, and 6% for project *A*, *B*, and *C* respectively. Delays on projects reflect severity of productivity problems (see Kometa, 1995). The severity of productivity problem and percentage delay (defined as the difference between actual time and contract time divided by the contract time) is shown in Figure 10.4. Mathematically, the relationship between severity and delay as influenced by productivity problems can be expressed as:

$$Y_t = 5X_t \quad \text{...(10.3)}$$

where Y_t = % severity of the productivity problem

X_t = % delay (different between planned contract time and actual time divided by contract time).

Y_t = 100% when delay is equal to or more than 20%, and 0% when delay is less or equal to 0%.

Severity	0%	25%	50%	75%	100%
% delay	≤0%	5%	10%	15%	≥20%

Figure 10.4. Nominal Scale for Severity of Productivity Problem (After Kometa, 1995).

Using formula 10.3, the severity of the three projects were calculated as 0.90 (i.e. 5*18%), 0.55 (i.e. 5*11%) and 0.30 (i.e. 5*6%) for project *A*, *B*, and *C* respectively with 1.00 representing "severe problem", 0.75 "medium problem" and 0.50 "low problem". The Project managers on the 3 case studies rated the severity of productivity problems as shown on Table 10.11. For example, project *A* had very severe productivity problems in 'lack of material', 'lack of proper tools' and so on, only 'changing of craftsmen' and 'Working overtime' were not severe.

Table 10.11 Data of 3 Case Studies.

Problems	Project *A*	Project *B*	Project *C*
Lack of material	1.00	1.00	0.50
Rework	1.00	0.75	0.75
Supervision delay	1.00	0.50	0.50
Interference	1.00	1.00	0.50
Changing of craftsmen	1.00	0.50	0.75
Changing of foremen	1.00	0.50	0.50
Over crowding	0.50	0.50	0.50
Absenteeism	1.00	0.75	0.50
Working Overtime	0.50	0.75	0.50
Equipment breakdown	1.00	1.00	0.50
Lack of tools	1.00	0.75	0.50
Delays	18%	11%	6%

Table 10.12 exhibits the results of these input using CONPAS. The overall severity indices of the productivity problem were 0.92, 0.50 and 0.26 for project *A*, *B*, and *C* respectively.

The average percentage error of the three cases was 8.21% where error of project *A* 2.22%, *B* 9.09%, and *C* 13.33%. The productivity problems in project *A* would suggest that site management should take emergency action beginning with problems that have the highest severity indices i.e., 'lack of material problems', 'rework', 'worker interference', and 'absenteeism. Project *B* should pay attention to 'lack of material' and 'worker interference', whilst Project *C* seems to be all right with only a little problem with 'rework'. If the relationship between project delays and problem severity is valid, it would seem from the analysis above that CONPAS will be a very good tool for diagnosing productivity problems on Indonesia construction site.

Table 10.12 Comparison of Project Delay and CONPAS Diagnosis of Problem Severity on the 3 Cases.

Productivity Problems	Project *A*		Project *B*		Project *C*	
	Frequency	Severity Index	Frequency	Severity Index	Frequency	Severity Index
Lack of material	1.00	0.93	1.00	0.93	0.50	0.19
Rework	1.00	0.86	0.75	0.52	0.75	0.52
Supervision delay	1.00	0.74	0.50	0.15	0.50	0.15
Interference	1.00	0.84	1.00	0.84	0.50	0.17
Changing of craftsmen	0.50	0.15	0.50	0.15	0.50	0.15
Changing of foremen	1.00	0.72	0.50	0.14	0.50	0.14
Over crowding	1.00	0.71	0.50	0.14	0.75	0.43
Absenteeism	1.00	0.80	0.75	0.48	0.50	0.16
Working Overtime	0.50	0.71	0.75	0.43	0.50	0.14
Equipment breakdown	1.00	0.76	0.75	0.30	0.50	0.15
Lack of tools	1.00	0.76	0.50	0.30	0.50	0.15
Total (CONPAS)		0.92		0.50		0.26
Y_t (PMs)		0.90		0.55		0.30
Error		0.02		0.05		0.04
% Error		2.22		9.09		13.33

10.6 Summary

This chapter has described a research aimed at developing a construction productivity audit system for improving on-site productivity in high-rise building construction (CONPAS). The related areas that need to be taken into account when diagnosing site productivity of building construction have been addressed. Influencing factors and their parameter for improving site productivity have been represented in the form of rules, using the expert system shell VP-EXPERT. The conclusions from the study can be summarised as follows:

Construction productivity researches can be categorised into two levels: The macro level or industry level and micro or site level. Much of the researches tend to be conducted at site level, because of their applicability, and ease of obtaining data.

Part of the knowledge base installed in this system was obtained from construction sites in Indonesia. The system consists of five modules that can be run separately or continuously.

1. Module one: Identification of the Productivity Problem.
2. Module two: Method and Technology, and its effects on-site productivity.
3. Module three: Site Management and its influence on-site productivity.
4. Module four: Working Environment and its influences on on-site productivity.
5. Module five: Human Factors.

Since knowledge base is changeable from time to time, the knowledge base of this system is still improvable if new findings or experiences are gained from researches and practices. The criteria had been introduced to validate the productivity audit system, and process of validation had been explained.

CHAPTER 11

CHAPTER 11
CONCLUSION AND RECOMMENDATIONS

11.1 Conclusion

This thesis set out to evaluate construction productivity in Indonesia. To achieve this, characteristics of the construction industry in Indonesia were reviewed. This included investigation of construction organisations, environment, market, education, and workforce. Six common industry problems in developing countries were then investigated in greater detail through the prime movers of the Indonesian construction industry. Of these, underdevelopment of human resources, and poor productivity were identified as the most severe problems in Indonesian construction.

From literature review and preliminary investigation of the problems of construction industry in Indonesia, it was apparent that the country needed an efficient method for improving productivity. A framework for developing a construction productivity audit system was established. The fulcrum of this framework was to examine productivity problems in detail through the main construction site personnel. Characteristics of these site personnel (craftsmen, foremen, project managers) were then investigated using activity sampling, structured questionnaire and interview techniques.

The investigations examined in detail productivity problems, human resource issues and motivation. The problems identified were compared to other developed and developing countries. Results indicate that overall, respondents agree that 'lack of material', 'absenteeism', and 'interference' were the first three most severe productivity problems. Whilst craftsmen problems perception were broadly in line with the aggregate results, foremen perceived 'rework' 1st, 'lack of material' 2nd, and 'absenteeism' 3rd. Project managers perceived 'rework' 1st, with both 'Interference' and 'absenteeism' ranked second. Although not achieving the same order of ranking, craftsmen, foremen, and project managers broadly agree with the importance ranking of the productivity problems.

It would seem that construction productivity problems are universal in nature with 'lack of materials' and 'reworks' being the most severe. Whilst the ranking of the problems may slightly differ from one country to another, the same kind of problems recur from country to country. With respect to a study of craftsmen motivation, it was identified that 'fairness of pay', 'good relationship with work mates', 'overtime pay', 'bonus', and 'adequate safety' are the most influential motivators for the construction workers in Indonesia. Indonesian and Nigerian operatives have similar motivators with physiological needs ranking highest on the priority list, followed by good relationship with their workmates. 'Disrespect by supervisor', 'little accomplishment', 'lack of co-operation amongst workmates', 'discontinuity of work', and 'unsafe working condition' are the most demotivators.

An attempt was made to benchmark construction productivity in the country by a study of regional variations in construction productivity with Yogyakarta as the benchmark. Jakarta craftsmen were found to be better than those in other regions in terms of production output, skill, and motivation. Also Jakarta construction foremen were found to be better supervisors, and better motivated, and likely to be paid more than those in other regions. Craftsmen's and foremen's productivity from regions outside Java were found to be relatively poorer than those in Java. The first regional construction productivity indices in Indonesia have been established from the results of this research. Hopefully, this would provide a human resource planning information base for the contractors when bidding for projects in regions they are less familiar with.

Factors for improving on-site productivity were prioritised through a structured survey of 26 project managers. 'Planning and scheduling', 'method of construction', 'work measurement', and 'sequence of works' achieved high priority rankings.

Based on the findings regarding identification of productivity problems through craftsmen, foremen, and project managers, and productivity improvement priorities extracted from

PMs and experts, a productivity audit system was developed. Using knowledge based system development approach, the audit system was developed using an expert system shell VP-Expert. The audit system was validated on 3 case study projects in Indonesia and found to be capable of problem diagnosis and provide a reliable training tool for construction productivity.

11.2 Advantages of CONPAS

Construction in Indonesia is facing challenges not only of increasing project complexity but also International competition. Foreign contractors with more construction experience and sophisticated technology are following investors into the country to participate and invest in infrastructural development. Local contractors in Indonesia should prepare to improve their productivity through a effort directed at diagnosing their production problems and training their men to solve / remove production bottlenecks as and when they occur on site. Adopting CONPAS will be a step in the right direction. The potential benefit of the system are:

1. The system has the potential to permit inexperienced or less experienced site managers to get first level advice on strategic and operational decision making on the site management issues that impinge on productivity.
2. Each module of the system can generate a report for users about the present condition of each factor on a project, which can be compared with benchmark. At final run, guideline for improvement is provided.
3. Human expertise is not permanent; experienced site personnel may leave the contractors for many reasons, taking their specialist knowledge with them. CONPAS can act as an archive for knowledge, thereby providing a means of capturing and storing some limited, but possibly very valuable expertise of a previous employee.
4. The system is user-friendly and considered to reach a similar decision as an expert does, but faster.
5. The system can be used as an instruction tool for training new site managers.

11.3 Future Research

To quantify production output, there is an urgent need to establish standard times for various construction activities using work study techniques. This can be initiated by Government through the Ministry of Public Work, and co-ordinated through construction industry associations such as the Contractor Association of Indonesia (GAPENSI), academics, and research institutions.

There is a continuing need for institutional strengthening and manpower development in the areas of project management, information technology includes data base management system. Since present construction methods are predominantly capitals-intensive, labour intensive methods should be encouraged through the use of direct labour organisations. Aid agencies such as the World Bank should assist developing countries to research appropriate technology and construction management techniques which are suited to their particular environment. The host governments could also achieve this through well packaged technology-transfer agreements with international contractors operation in their countries.

What would the implication of an increasing emphasis on productivity improvement in a labour intensive environment be? There would obviously be safety issues which have so far received little attention in Indonesia and many developing countries. Recognising this, the Indonesian Government has recently introduced 'JAMSOTEK' (an insurance scheme for accident prevention) in which contractors are obliged to pay a certain premium to cover all personnel working on their construction sites for accidents. While its introduction is laudable, its effectiveness towards reducing accidents and changing attitudes to safety would need to be continuously evaluated / monitored.

In many cases, the research environment where a knowledge based system such as CONPAS is developed, may differ from the user environment. This may cause a considerable reduction in the accuracy of the system. Therefore, continuous refinement of the knowledge base and restructuring of CONPAS should be provided.

CONPAS is a knowledge based system for construction management, with a qualitative approach. At final run it also provides general guidelines in the form of advice on what to do. In future, these guidelines can refer to a package to solve a particular problem in improving site productivity, for instance: Construction method selection, effective organisation for a particular site, site layout design, and equipment selection.

Since CONPAS has the knowledge base for building construction, other civil works are fertile areas for creating similar knowledge based systems in the future, such as airport construction, bridge and highway, dams that have specific knowledge for engineering design, method of construction, site layout, construction planning and so on. Towards this end a general conceptual framework for improving site productivity is shown in Figure 11.1.

Maintenance of CONPAS in terms of updating the best practices obtained form future research, as well as further development such as a productivity audit system at company level is needed. Such as system can identify off-site factors that enhance on-site productivity. If CONPAS for on-site productivity and CONPAS for company performance are developed and integrated it can be used as self assessment tools in productivity / quality assurance to help contractors strengthen their competence and increase their competitiveness.

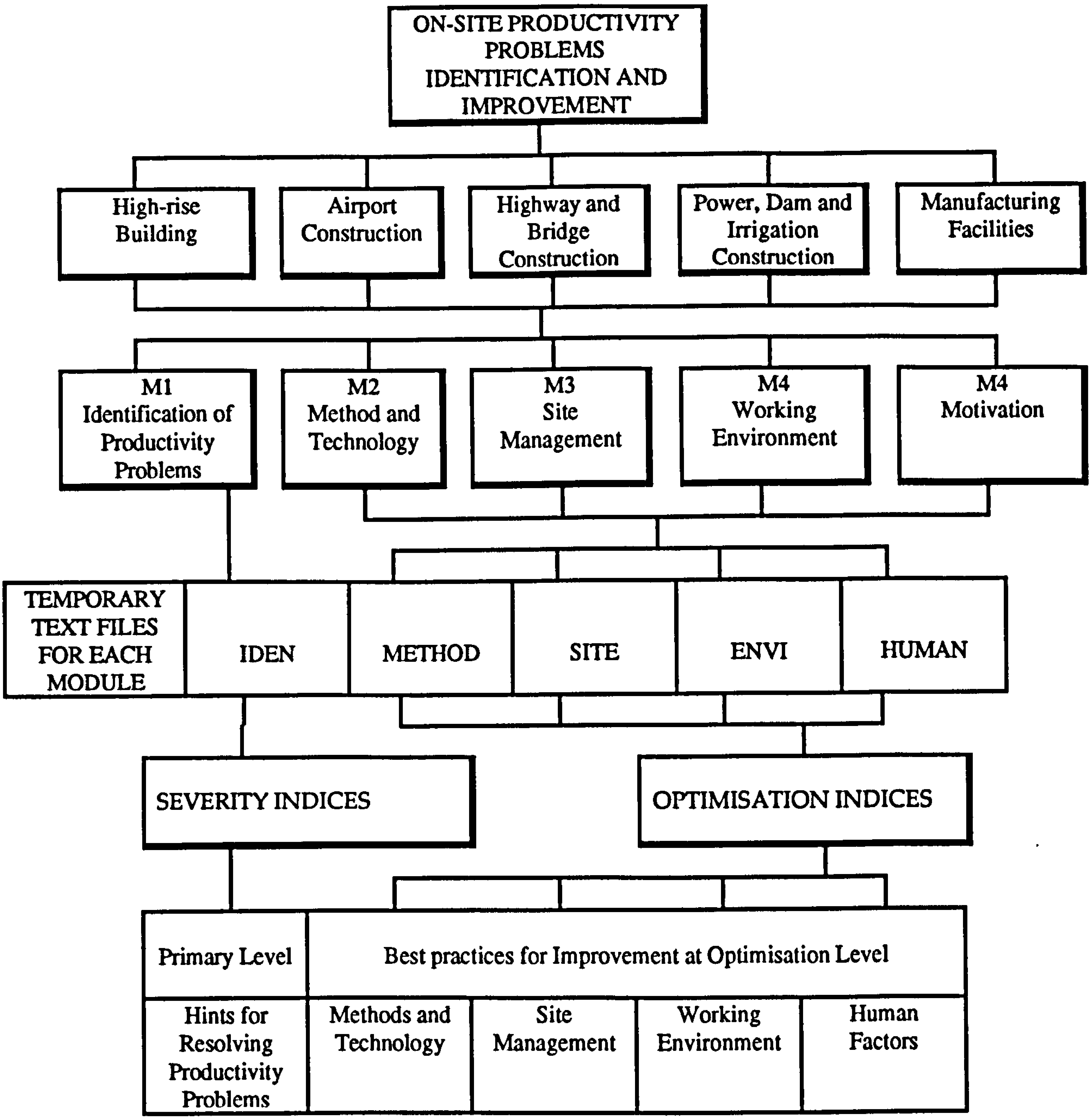

Figure 11.1. The Overall Conceptual Framework for Diagnosis On-site Productivity - Future Extension

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APPENDIX A

APPENDIX A

CRAFTSMAN ACTIVITY SAMPLING SHEET

Company	Total	**Start Time**	9.30
Project	Plaza View	**Finish Time**	13.40
Date	2nd Sept. 1994	**Target**	100%
Observer	Pontas Sianturi	**Achieve**	90%

Observation point	Constr. activity	Walk	Talk with supervisor	Talk with Workmate	Inactive	Total	Remark
1	ABC					3	
2	AB	C				3	
3	A		B	C		3	
4	AC				B	3	
5	BC	A				3	
6	ABC					3	
7	AB		C			3	
8	BC			A		3	
9	C	A	B			3	
10	ABC					3	
11	ABC					3	
12	ABC					3	
13	BC		A			3	
14	AB			C		3	
15	AC			B		3	
16	AC	B				3	
17	BC	A				3	
18	ABC					3	
19	ABC					3	
20	ABC					3	
21	AC		B			3	
22	A			B	C	3	
23	BC			A		3	
24	ABC					3	
25	ABC					3	
26	ABC					3	
27	ABC					3	
28	B		A		C	3	
29	ABC					3	
30	AC			B		3	
31	AC	B				3	
32	ABC					3	
33	ABC					3	
34	BC	A				3	
35	AB			C		3	
36	ABC					3	
37	ABC					3	
38	A	C			B	3	
39	ABC					3	
40	BC			A		3	
Total	93	8	6	9	4	120	

Note A, B, and C are particular trades (e.g. bricklayers) under observation

APPENDIX B

APPENDIX B

OPERATIVES QUESTIONNAIRE

The School of Construction Engineering and Technology University of Wolverhampton, UK and the University of Atma Jaya Yogyakarta, Indonesia are currently engaged in a number of research projects aimed at improving construction productivity. Having realized the paramount importance of construction operative in the construction process, this research aims at identifying the different variables affecting their productivity. This questionnaire is designed in a way that you can make suggestions thereby making your invaluable contributions to this work. Your sincere and frank answers to the questions will be much appreciated. All answers will be treated in absolute confidence and used only for academic purposes. Extra space is provided to enable you expand your answers to the questions where necessary. Thank you.

SECTION 1. PERSONAL DATA

1. Name and Location of your present site ....

....

2. What is your age group in years?
[a] 15-20. [b] 20-30. [c] 30-40 [d] 40-50 [e] Above 50.

3. What is your construction experience in years?
[a] 0-2 [b] 2-5. [c] 5-10. [d] 10-20. [e] Above 20.

4. How were you trained ?
[a]. Apprenticeship
[b]. Trade school
[c]. On site experience
[e]. Special training by Department of Labour.
[f]. ....

5. How many years of your experience in the following categories:

Classification	Years
1. Housing	
2. Public Building.	
3. Industrial.	
4. Commercial	

SECTION 2. OPERATIVE / EMPLOYER RELATION.

1. Under which of these are you currently employed?
[a]. Subcontractor (Labour only).
[b]. Subcontractor.
[c]. Main contractor.
[d]. ....

2. How long in year have you been with your present employer?
[a] 0-2 [b] 2-5 [c] 5-10 [d] 10-20 [e] Over 20 years.

3. How long in months have you been on this present site?
[a] 0-3 [b] 3-6 [c] 6-12 [d] Over 12 months.

4. How would you rate the following on your site?

Categories	**Very good**				**Very poor**
1. Construction method	5	4	3	2	1
2. Site management	5	4	3	2	1
3. Working Environment	5	4	3	2	1
4. Worker's payment	5	4	3	2	1

SECTION 3. OUTPUT AND METHODS.

1. What is your normal gang size? (Craftsman : Labourers)
[a] 5:1 [b] 4:1 [c] 3:1 [d.] 2:1 [e] 1:1 [f] 1:2

2. What do you think the ideal gang size should be?
[a] 5:1 [b] 4:1 [c] 3:1 [d] 2:1 [e] 1:1 [f] 1:2

3. What is the normal output per day in your current task?
Gang :..per day

You contribute on as an individual :...............................percentage to gang output.

4. What is your degree of satisfaction with this output level?
[a] Very satisfied. [b] Satisfied. [c] Not satisfied.

5. Given all favourable condition, what do you think is the highest output you/your gang can achieve in your task?
Ideal output of gang :.. per day.

You contribute on as an individual:..............................percentage to gang output.

6. How would you classify your energy input into your work?
[a] Very strenuous. [b] Strenuous. [c] Just OK.

7. In a typical working day, How many hours of your time is lost in the following classifications in a working week :

Classes	Estimated hours lost per week
1. Internal delay	
2. Lack of skill	
3. Waiting & Relaxation	
4. Supervision	
5. Extra breaks	
6. Official breaks	

SECTION 4. PRODUCTIVITY

1. Underlisted are some of the problems which may be influencing your productivity. Kindly tick ( ) if it is a problem on your present site in column 2 and give estimate (in hours) of how much time is lost per week traceable to this problem in the third column.

Example:

Problem	Response	Estimated lost hour/week.
Lack of material	[y] [n]	3

Problem	Response	Lost hour per week
1. Lack of material	[y] [n]	
2. Lack of tools	[y] [n]	
3. Equipment breakdown	[y] [n]	
4. Repeat work.	[y] [n]	
5. Changing crew members.	[y] [n]	
6. Interference.	[y] [n]	
7. Absenteeism.	[y] [n]	
8. Supervision delay.	[y] [n]	
9. Changing supervisor.	[y] [n]	
10. Work pressure.	[y] [n]	
11. Overcrowding	[y] [n]	
12		

2. Underlined are some of the probable causes of non availability of materials when needed by your work on site. If they correspond to the causes of this problem on your site , tick ( ) the cause and rank in order of importance i.e. 1st., 2nd., 3rd., 4th.,....

Statements	Ranks
On site transporting difficulties.	[ ]
Excessive paper work for requisitions.	[ ]
Improper material delivered to site	[ ]
Lack of proper planning.	[ ]

3. How much influence does having to stop work, wait or move to a different spot because of lack of materials or tools have on your daily output?
a. Great Influence. b. Average influence. c. No influence.

4. Just as in question 2 above, probable causes of repeat work are underlisted. Please tick ( ) and rank in order of importance.

Statements	Ranks
1. Poor instruction	[ ]
2. Change of instruction	[ ]
3. Poor workmanship	[ ]
4. Complex specification	[ ]

5. How effective do you think are the following ways to avoid rework ?

Statements	Effective				Poor
1. Right and clear drawing.	5	4	3	2	1
2. Clear and written instruction.	5	4	3	2	1
3. A brief query meeting every beginning of a task.	5	4	3	2	1
4. Others					

SECTION 5. LABOUR TURNOVER

1. Do workers get fired or quit job on this site?
[a] Yes [b] No.

2. For every ten people that leave their jobs on this site, how many people
   1. Quit =..........................
   2. Are fired =..........................

3. Please rank the following reasons way workers in your gang leave their jobs:

Statements	Ranks
1. Getting better pay on other sites.	[ ]
2. Getting another job site near their home.	[ ]
3. Getting better challenge with respect to their skill.	[ ]
4. Better working environment.	[ ]

4. Is your gang slowed down by worker joining and leaving the job?
[a] Yes. [b] No.

SECTION 6. MOTIVATION

1. Below is a table of construction situations that can motivate you to higher productivity. You are requested to indicate the level of importance ranging from: **Very Important (4), Important (3) , Not So Important (2), Not Important (1), and Not relevant (0)** of each to you. Kindly tick ( ) how prevalent are these factors on this site on a scale: **High (3), Medium (2), and Low (1).** You can add other relevant factors.

MOTIVATING FACTORS LEVEL OF IMPORTANCE LEVEL OF THIS SITE

Example:
Manager treats me a cigarette. 4 3 2 1 0 3 2 1

Motivating factors	Level of importance					Level of this site		
1. Good relations with work mates	4	3	2	1	0	3	2	1
2. Good safety programmes	4	3	2	1	0	3	2	1
3. The work itself	4	3	2	1	0	3	2	1
4. Over time	4	3	2	1	0	3	2	1

5. Fairness of pay	4	3	2	1	0	3	2	1
6. Recognition on the job	4	3	2	1	0	3	2	1
7. Accurate description of work to be done	4	3	2	1	0	3	2	1
8. Participation in decision.	4	3	2	1	0	3	2	1
9. Good supervision.	4	3	2	1	0	3	2	1
10. Promotion.	4	3	2	1	0	3	2	1
11. More responsibility.	4	3	2	1	0	3	2	1
12. Challenging task	4	3	2	1	0	3	2	1
13. Job security.	4	3	2	1	0	3	2	1
14. Choosing workmates	4	3	2	1	0	3	2	1
15. Bonus.	4	3	2	1	0	3	2	1

2. As above, You are requested to rank the level of importance of the following factors which are capable of causing a loss of your enthusiasm to work and the levels to which they are met on your present site.

Demotivating factors Level of importance Level of this site

Example:

Disrespectful 4 3 2 1 0 3 2 1

Demotivating factors	Level of Importance					Level of this site		
1. Disrespectful supervisor	4	3	2	1	0	3	2	1
2. Little accomplishment	4	3	2	1	0	3	2	1
3. Discontinuity of work	4	3	2	1	0	3	2	1
4. Lack of recognition.	4	3	2	1	0	3	2	1
5. Under-utilisation of skill	4	3	2	1	0	3	2	1
6. Incompetence of work-mates	4	3	2	1	0	3	2	1
7. Lack of cooperation among mates	4	3	2	1	0	3	2	1
8. Poor inspection programme	4	3	2	1	0	3	2	1
9. Unsafe condition	4	3	2	1	0	3	2	1

10. Productivity urged but no one cares	4	3	2	1	0	3	2	1
11. Hot weather.	4	3	2	1	0	3	2	1
12. Not enough work.	4	3	2	1	0	3	2	1

SECTION 7. FOREMAN LEADERSHIP

1. Below is a table of the qualities of a good foreman based on five facets: problem solving, administration, supervision team management, interpersonal relation, and personal quality. Rate the importance of the factors ranging from very important to not considered as in previous question. Then rate your direct foreman in one of the three levels (High = 3, Medium = 2 , Low = 1) in each factor.

Factors	Level of importance	Frequency
Example: Making decision quickly	4 3 2 1 0	3 2 1

Factors	Level of Importance					Frequency		
1. Is creative when it comes to problem solving.	4	3	2	1	0	3	2	1
2. Make decision quickly	4	3	2	1	0	3	2	1
3. Takes into account preferences of workers.	4	3	2	1	0	3	2	1
4. Has work well planned.	4	3	2	1	0	3	2	1
5. Stresses on safety.	4	3	2	1	0	3	2	1
6. Lay out work quickly.	4	3	2	1	0	3	2	1
7. Is good at motivating people	4	3	2	1	0	3	2	1
8. Is willing to accept suggestion.	4	3	2	1	0	3	2	1
9. Accepts responsibility for work.	4	3	2	1	0	3	2	1
10. Give clear directions	4	3	2	1	0	3	2	1
11. Plays no favorites among workers.	4	3	2	1	0	3	2	1
12. Has a lot of self confidence.	4	3	2	1	0	3	2	1
13. Is proud of work and crew.	4	3	2	1	0	3	2	1
14. Is evenly tempered.	4	3	2	1	0	3	2	1

APPENDIX C

APPENDIX C

FOREMEN QUESTIONNAIRE

The School of Construction Engineering and Technology University of Wolverhampton, UK and University of Atma Jaya Yogyakarta, Indonesia are currently engaged in a number of research projects aimed at improving construction productivity. Having realized the paramount importance of construction foreman in the construction process, this research aims at identifying the different variables affecting their productivity. This questionnaire is designed in a way that you can make suggestions thereby making your invaluable contributions to this work. All answers will be treated in absolute confidence and used only for academic purposes. Extra space is provided to enable you expand your answers to the questions where necessary. Thank you.

SECTION 1. PERSONAL DATA

1. Name and Location of your present site..

....

2. What is your age group in years?
[a] 20-30. [b] 30-40. [c] 40-50. [d] Above 50.

3. What is your construction experience in years?
[a] 2-5. [b] 5-10. [c] 10-20. [d] Above 20.

4. How were you trained ?
[a]. Apprenticeship
[b]. Trade school
[c]. On site experience
[d]. Special training by Department of Labour.
[f]. ....

5. How many years your construction experience under the following project classifications:

Classification	Years
[a]. Housing	
[b]. Public Building.	
[c]. Industrial.	
[d]. Commercial.	
[e].	
[f].	

SECTION 2. INDUSTRIAL RELATION.

1. Under which of these are you currently employed?
[a]. Subcontractor (Labour only).
[b]. Subcontractor.
[c]. Main contractor.
[d]. ....

2. How long (in year) have you been with your present employer?
[a] 0-2. [b] 2-5. [c] 5-10. [d] 10-20. [e]Over 20.

3. How long (in months) have you been on this present site?
[a] 0-3. [b] 3-6. [c] 6-12. [d] Over 12.

4. How would you rate the following categories on your site?

Categories	**Very good**				**Very poor**
1. Construction method	5	4	3	2	1
2. Site management	5	4	3	2	1
3. Working Environment for foremen	5	4	3	2	1
4. Level of payment for foremen	5	4	3	2	1

5. What does the site management know about your work?
[a] Its progress. [b] Its delays [c] Nothing.

6. How aware are you of how your work fits into the programme and profit being made by your employer on this project?
[a] Very aware [b] Aware [c] Not aware

7. If you are aware, what efforts do you make to ensure your project's progress?
[a] Advice your direct superior on best methods to adopt.
[b] Adopt or devise better methods.
[c] ....
[d] ....

8. To what degree are the following characteristics present in your direct superior?

Characteristics	**Agree**				**Disagree**
Around when needed.	5	4	3	2	1
Friendly and approachable.	5	4	3	2	1
Knowledgeable of his job.	5	4	3	2	1
Skillful.	5	4	3	2	1
Keeps all project information to himself.	5	4	3	2	1
Listen to and consider suggestions.	5	4	3	2	1

9. How do you rate the level of coordination amongst foremen on this site?
[a] Very good. [b] Good. [c] Just fine. [d] Poor.

10. How do you rate the goodness of the foremen coordination can effect your craftsmen productivity.
[a] Highly improve. [b] Improve.
[c] Just little effect. [d] No effect at all.

SECTION 3. SPAN OF CONTROL AND METHODS.

1. What is your normal span of control? (Foreman : Craftsmen)
[a] 1 : 3 to 5 [b] 1 : 6 to 8 [c] 1 : 9 to 12 [d] 1 : 12 to 15 [e] 1 : Greater than 15

2. What do you think the ideal span of control size should be?
[a] 1 : 3 to 5 [b] 1 : 6 to 8 [c] 1 : 9 to 12 [d] 1 : 12 to 15 [e] 1 : Greater than 15

3. What is your degree of satisfaction with the current of span of control?
[a] Very satisfied [b] Satisfied. [c] Not satisfied.

4. How would you classify your mental condition in performing your work?
[a] Very stress. [b] Stress. [c] Just OK.

5. In a typical working week, How many hour do you spend time in the following classifications:

Classes	Hours spent in a typical working week
Control work pace and quality	
Giving instruction	
Read construction programme and drawings	
Plan work	
Work with hands	
Complete records	
Fetch and distribute material	
Participate in meetings	
Talk on phone	
Travel away from site	
Other activities	

SECTION 4. PRODUCTIVITY

1. Underlisted are some of the problems which may be effecting your craftsmen productivity. Kindly tick ( ) the importance of each factor ranging from Very important (4) to not important (1), or (0) for not considered. Then please tick ( ) their level on your present site ranging from **High** (3) to **Low (1)** in column 2 in the last four weeks.

Problem	Level of Importance	Frequency of Occurring
Example:		
Lack of material	4 3 2 1 0	3 2 1

Problems	**Level of Importance**					**Frequency of Occurring**		
Lack of material	4	3	2	1	0	3	2	1
Lack of tools	4	3	2	1	0	3	2	1
Equipment breakdown	4	3	2	1	0	3	2	1
Repeat work.	4	3	2	1	0	3	2	1
Changing crew members.	4	3	2	1	0	3	2	1
Interference.	4	3	2	1	0	3	2	1
Absenteeism.	4	3	2	1	0	3	2	1
Supervision delay.	4	3	2	1	0	3	2	1
Overcrowding.	4	3	2	1	0	3	2	1
Changing foreman	4	3	2	1	0	3	2	1
Working overtime	4	3	2	1	0	3	2	1

2. Underlined are some of the probable on-site causes of non availability of materials when needed by the craftsmen under your supervision. If they correspond to the causes of this problem on your site , tick ( ) the cause and rank in order of importance i.e. 1st., 2nd., 3rd., 4th.,....

Causes of material unavailability	**Ranks**
1. On site transporting difficulties.	[ ]
2. Excessive paper work for requisitions.	[ ]
3. Improper material delivered to site.	[ ]
4. Lack of proper planning.	[ ]
5.	
6.	

3. Just as in question 2 above, probable causes of repeat work are underlisted. Please tick ( ) and rank in order of importance.

Causes of repeat work	Ranks
a. Poor Instruction	[ ]
b. Change of instruction.	[ ]
c. Poor workmanship.	[ ]
d. Complex Specification	[ ]
e.	
f.	

SECTION 5. FOREMAN MOTIVATION

1. Below is a table of construction situations that can motivate you to higher productivity. You are requested to indicate the level of importance ranging from: Very Important (4), Important (3), Not So Important (2), Not Important (1), and Not Considered (0) of each to you. Then kindly tick ( ) their application on your site: **High (3), Medium (2), and Low (1).** You can add other factors deemed fit.

MOTIVATOR FACTORS IMPORTANCE LEVEL OF THIS SITE

Example:
Manager treats me a cigarette. 4 3 2 1 0 3 2 1

Motivating factors	Level of importance					Level of this site		
1. Good relations with other foreman.	4	3	2	1	0	3	2	1
2. Good safety programmes	4	3	2	1	0	3	2	1
3. The work itself	4	3	2	1	0	3	2	1
4. Over time	4	3	2	1	0	3	2	1
5. Fairness of pay	4	3	2	1	0	3	2	1
6. Recognition on the job	4	3	2	1	0	3	2	1
7. Accurate description of work to be done	4	3	2	1	0	3	2	1
8. Participation in decision making.	4	3	2	1	0	3	2	1
9. Good management.	4	3	2	1	0	3	2	1
10. Promotion.	4	3	2	1	0	3	2	1
11. More responsibility.	4	3	2	1	0	3	2	1

12. Challenging task	4	3	2	1	0	3	2	1
13. Job security.	4	3	2	1	0	3	2	1
14. Good relation with your subordinates	4	3	2	1	0	3	2	1
15. Bonus.	4	3	2	1	0	3	2	1
16.								
17								

2. As above, You are requested to rank the level of importance of the following factors which are capable of causing a loss of your enthusiasm to work and the levels to which they are met on your present site.
Example:

Demotivating factors	Level of importance					Level of this site		
Disrespectful	4	3	2	1	0	3	2	1

Demotivating factors	**Level of Importance**					**Level of this site**		
1. Disrespectful Site Manager	4	3	2	1	0	3	2	1
2. Little accomplishment	4	3	2	1	0	3	2	1
3. Discontinuity of work	4	3	2	1	0	3	2	1
4. Lack of recognition.	4	3	2	1	0	3	2	1
5. Under-utilisation of skill	4	3	2	1	0	3	2	1
6. Incompetence of superiors	4	3	2	1	0	3	2	1
7. Lack of cooperation amongst foremen	4	3	2	1	0	3	2	1
8. Poor construction programme	4	3	2	1	0	3	2	1
9. Unsafe condition	4	3	2	1	0	3	2	1
10. Productivity urged but no one cares	4	3	2	1	0	3	2	1
11. Hot weather.	4	3	2	1	0	3	2	1
12. Not enough work.	4	3	2	1	0	3	2	1
13. Low pay	4	3	2	1	0	3	2	1

SECTION 6. PROJECT MANAGER LEADERSHIP

1. Below is a table of the good quality a project manager should posses based on five facets: problem solving, administration, supervision team management, interpersonal relation, and personal quality. Rate the importance of the factors ranging from very important (4) to not considered (0). Then rate your direct foreman in three levels (High = 3 , Medium = 2 , Low = 1) in each factor.

Factors	Level of importance	Frequency
Example: Making decision quickly	4 3 2 1 0	3 2 1

Factors	Level of Importance					Frequency		
1. Creative when it comes to problem solving.	4	3	2	1	0	3	2	1
2. Make decision quickly	4	3	2	1	0	3	2	1
3. Takes subordinates into account in decision making.	4	3	2	1	0	3	2	1
4. Has work well planned.	4	3	2	1	0	3	2	1
5. Concerned about on-site safety.	4	3	2	1	0	3	2	1
6. Lay out work quickly.	4	3	2	1	0	3	2	1
7. Good at motivating people	4	3	2	1	0	3	2	1
8. Willing to accept suggestion.	4	3	2	1	0	3	2	1
9. Accepts responsibility for work.	4	3	2	1	0	3	2	1
10. Give clear directions	4	3	2	1	0	3	2	1
11. Has no favorites among his subordinates.	4	3	2	1	0	3	2	1
12. Has a lot of self confidence.	4	3	2	1	0	3	2	1
13. Is proud of work and crew.	4	3	2	1	0	3	2	1
14. Is evenly tempered.	4	3	2	1	0	3	2	1

APPENDIX D

APPENDIX D

PROJECT MANAGER QUESTIONNAIRE

The School of Construction Engineering and Technology, University of Wolverhampton, United Kingdom and the University of Atma Jaya Yogyakarta, Indonesia are currently conducting a series of studies into construction productivity in Indonesia. The aim of these studies is to evaluate construction productivity in Indonesia and develop a productivity audit system for improving it. This questionnaire is designed in a way that you can make suggestions thereby making your invaluable contributions to this work. All answers will be treated in absolute confidence and used only for academic purposes. Your co-operation is appreciated.

SECTION 1 GENERAL INFORMATION

1. How long have you been in the construction business?
[a] 0-5. [b] 5-10. [c] 10-15. [d] 15-20. [e] Over 20 years.

2. Type of the construction industry: Please tick ( )

1	Housing	
2	High-rise building	
3	Manufacturing/utilities facilities.	
4	Highway and bridge.	
5	Dam and irrigation.	
6	Offshore construction.	
7	Other	

3. Firm's Catchment Area.
[a] Local (Province). [b] National. [c] International.

4. Type of ownership
[a] Private. [b] State owned. [c] Joint venture.

5. Information of the present project.

1	Contracts sum (in Rp)	
2	Contract duration (in day)	
3	% Completed	
4	Current % delay	

6. What percentage of your project expenditure do you predict will go into the following:

no	Project expenditure items	Percentage
1	Site overheads	
2	Labour.	
3	Equipment	
4	Material	
		100

SECTION 2. DELAY AND COST OVERRUN.

1. What percentage of your contracts are completed on time?
[a] 10-30% [b] 30-50% [c] 50-70% [d] 70-90% [e] over 90%

2. Please rank the following causes of delay in order of importance, ranging from **(Very important = 4 to Not important = 1 or Not considered = 0)**. Please rate the factors on your current project from: **High (3), Medium (2), and Low (1)** under the frequency column.

no	Causes of delay	Level of importance					Frequency		
1	Unpredictable weather condition	4	3	2	1	0	3	2	1
2	Inaccuracy of material estimate.	4	3	2	1	0	3	2	1
3	Inaccurate prediction of craftsmen production rate	4	3	2	1	0	3	2	1
4	Inaccurate prediction of equipment production rate	4	3	2	1	0	3	2	1
5	Material shortage	4	3	2	1	0	3	2	1
6	Equipment shortage	4	3	2	1	0	3	2	1
7	Skilled labour shortage	4	3	2	1	0	3	2	1
8	Locational restriction of the project	4	3	2	1	0	3	2	1
9	Inadequate planning.	4	3	2	1	0	3	2	1
10	Low labour productivity.	4	3	2	1	0	3	2	1
11		4	3	2	1	0	3	2	1

3. What percentage of your contracts are completed on budget?
[a] 10-30% [b] 30-50% [c] 50-70% [d] 70-90% [e] Over 90%

4. Please rank the following causes of cost overrun in order of importance, ranging from (**Very important = 4 to Not important = 1 or Not considered = 0**). Please rate the factors on your current project from: **High (3), Medium (2), and Low (1)**under the frequency column.

no	Cause of cost overrun	Level of importance					Frequency		
1	Unpredictable weather condition.	4	3	2	1	0	3	2	1
2	Material cost increased by inflation	4	3	2	1	0	3	2	1
3	Inaccurate material estimate.	4	3	2	1	0	3	2	1
4	Project site difficulty.	4	3	2	1	0	3	2	1
5	Lack of experience of project geographical location.	4	3	2	1	0	3	2	1
6	Lack of experience of project type.	4	3	2	1	0	3	2	1
7	Lack of experience of local regulation.	4	3	2	1	0	3	2	1
8		4	3	2	1	0	3	2	1
9		4	3	2	1	0	3	2	1

SECTION 3. SUBCONTRACTOR EMPLOYMENT.

1. Do you employ subcontractors for some of your operations?
   [a]. Yes [b]. No

2. If yes, the following may correspond to your reasons for using them? Please rank them in order of importance: ie. **1st, 2nd, 3rd.....**

No	Reasons	Rank
1	Reduce workload.	
2	Increase profit.	
3	Workers are more productive under them	
4	Reduce financial risk.	
5	No expertise for a certain part of work.	
6	Special reliable skilled trade not available	
7		

3. What are the basic considerations in the choice of sub-contractors for your work? Please rank them in order of importance. ie. **1st, 2nd, 3rd.....**

No	Consideration	Rank
1	Work programme enforces the use of a particular sub-contractor.	
2	Efficiency shown in previous work experience.	
3	Subcontractor has better resources.	
4		
5		

SECTION 4. LABOUR PRODUCTIVITY PROBLEM

1. Underlisted are some of the problems which may be influencing your craftsmen productivity. Kindly tick ( ) the importance of each factor to on-site productivity ranging from **Very important (4) to not important (1), or (0) for not applicable.** Then please tick ( ) your current rating of these problems on your present site in the last four weeks ranging from **High (3) to Low (1)** at your present site under the frequency column.

Problem Level of Importance Frequency of Occurrence

Example:
Lack of material 4 3 2 1 0 3 2 1

Problems	**Level of Importance**					**Frequency of Occurrence**		
Lack of material	4	3	2	1	0	3	2	1
Lack of tools	4	3	2	1	0	3	2	1
Equipment breakdown	4	3	2	1	0	3	2	1
Repeat work.	4	3	2	1	0	3	2	1
Changing crew members.	4	3	2	1	0	3	2	1
Interference.	4	3	2	1	0	3	2	1
Absenteeism.	4	3	2	1	0	3	2	1
Supervision delay.	4	3	2	1	0	3	2	1
Overcrowding.	4	3	2	1	0	3	2	1
Changing foreman	4	3	2	1	0	3	2	1
Working overtime	4	3	2	1	0	3	2	1

2. Underlined are some of the probable on-site causes of non availability of materials when needed by craftsmen under your supervision. If they correspond to the causes of this problem on your site , tick ( ) the cause and rank in order of importance i.e. 1st., 2nd., 3rd., 4th.,....

Causes of material unavailability	Ranks
1. On site transportation difficulties.	[ ]
2. Excessive paper work for requisitions.	[ ]
3. Improper material delivered to site.	[ ]
4. Lack of proper planning.	[ ]
5. .Supplier delay.	[ ]
6.	

3. Just as in question 2 above, probable causes of repeat work are underlisted. Please tick ( ) and rank in order of importance, ie. 1st, 2nd, 3rd, ...

Causes of repeat work	Ranks
a. Poor Instruction	[ ]
b. Change of instruction.	[ ]
c. Poor workmanship.	[ ]
d. Complex Specification	[ ]
e.	
f.	

SECTION 6. CONTRACT MANAGER LEADERSHIP

1. Below is a table of the good qualities a Contract manager should possess based on five facets: problem solving, administration, supervision team management, interpersonal relation, and personal quality. Rate the importance of the factors ranging from **very important (4) to not applicable (0)** as previous question. Then rate your direct contract manager on three levels (**High = 3 , Medium = 2 , Low = 1**) in each factor.

Factors	Level of importance	Frequency
Example:		
Making decision quickly	4 3 2 1 0	3 2 1

Factors	Level of Importance					Frequency		
1. Creative when it comes to problem solving.	4	3	2	1	0	3	2	1
2. Makes decision quickly	4	3	2	1	0	3	2	1
3. Takes subordinates into account in decision making.	4	3	2	1	0	3	2	1
4. Plans work well.	4	3	2	1	0	3	2	1
5. Concern about on-site safety.	4	3	2	1	0	3	2	1
6. Lay out work quickly.	4	3	2	1	0	3	2	1
7. Good at motivating people	4	3	2	1	0	3	2	1
8. Willing to accept suggestion.	4	3	2	1	0	3	2	1
9. Accepts responsibility for work.	4	3	2	1	0	3	2	1
10. Give clear directions	4	3	2	1	0	3	2	1
11. Has no favorites amongst subordinates.	4	3	2	1	0	3	2	1
12. Has a lot of self confidence.	4	3	2	1	0	3	2	1
13. Is proud of work and crew.	4	3	2	1	0	3	2	1
14. Is evenly tempered.	4	3	2	1	0	3	2	1

SECTION 7: SITE PRODUCTIVITY

1. Please rate the following factors for their importance with respect to opportunity for improving on-site productivity in construction (**Very importance = 4, Importance = 3, Less importance = 2 , Not importance = 1, and Not applicable = 0).**

CATEGORIES	FACTORS	LEVEL OF IMPORTANCE				
Method and Technology	Engineering design	4	3	2	1	0
	Method of construction	4	3	2	1	0
	Sequence of works	4	3	2	1	0
	Work measurement	4	3	2	1	0
Site Management	Planning and scheduling	4	3	2	1	0
	Site layout	4	3	2	1	0
	Site communication	4	3	2	1	0
	Material management	4	3	2	1	0
	Equipment management	4	3	2	1	0
	Manpower management	4	3	2	1	0
Working environment	Safety measure	4	3	2	1	0
	Physical environment	4	3	2	1	0
	Supervision-quality	4	3	2	1	0
	Job security	4	3	2	1	0
	Job training	4	3	2	1	0
	Participation in planning	4	3	2	1	0
Human factors	Level of pay	4	3	2	1	0
	Satisfaction	4	3	2	1	0
	Financial incentive	4	3	2	1	0

	Fringe benefit	4	3	2	1	0
	Foreman-craftsmen relationship	4	3	2	1	0
	Peer relation	4	3	2	1	0
	Absenteeism	4	3	2	1	0

3. Please indicate the degree of influence of the following factors on effective use of resources on this site, ranging from 3 **for strong significance to 1 for weak significance and 0 for no significance.**

CATEGORIES	FACTORS	RESOURCE	LEVEL OF SIGNIFICANCE			
Method and Technology	Engineering design	TIME	3	2	1	0
		MATERIAL	3	2	1	0
		LABOUR	3	2	1	0
		PLANT	3	2	1	0
	Method of construction	TIME	3	2	1	0
		MATERIAL	3	2	1	0
		LABOUR	3	2	1	0
		PLANT	3	2	1	0
	Sequence of works	TIME	3	2	1	0
		MATERIAL	3	2	1	0
		LABOUR	3	2	1	0
		PLANT	3	2	1	0
	Work measurement	TIME	3	2	1	0
		MATERIAL	3	2	1	0
		LABOUR	3	2	1	0
		PLANT	3	2	1	0
Site Management	Planning and scheduling	TIME	3	2	1	0
		MATERIAL	3	2	1	0
		LABOUR	3	2	1	0
		PLANT	3	2	1	0
	Site layout	TIME	3	2	1	0
		MATERIAL	3	2	1	0
		LABOUR	3	2	1	0
		PLANT	3	2	1	0
	Site communication	TIME	3	2	1	0
		MATERIAL	3	2	1	0
		LABOUR	3	2	1	0
		PLANT	3	2	1	0

	Material management	TIME MATERIAL LABOUR PLANT	3 3 3 3	2 2 2 2	1 1 1 1	0 0 0 0
	Equipment management	TIME MATERIAL LABOUR PLANT	3 3 3 3	2 2 2 2	1 1 1 1	0 0 0 0
	Manpower management	TIME MATERIAL LABOUR PLANT	3 3 3 3	2 2 2 2	1 1 1 1	0 0 0 0
Working environment	Safety measure	TIME MATERIAL LABOUR PLANT	3 3 3 3	2 2 2 2	1 1 1 1	0 0 0 0
	Physical environment	TIME MATERIAL LABOUR PLANT	3 3 3 3	2 2 2 2	1 1 1 1	0 0 0 0
	Supervision-quality	TIME MATERIAL LABOUR PLANT	3 3 3 3	2 2 2 2	1 1 1 1	0 0 0 0
	Job security	TIME MATERIAL LABOUR PLANT	3 3 3 3	2 2 2 2	1 1 1 1	0 0 0 0
	Job training	TIME MATERIAL LABOUR PLANT	3 3 3 3	2 2 2 2	1 1 1 1	0 0 0 0
	Participation in planning	TIME MATERIAL LABOUR PLANT	3 3 3 3	2 2 2 2	1 1 1 1	0 0 0 0
Human factors	Level of pay	TIME MATERIAL LABOUR PLANT	3 3 3 3	2 2 2 2	1 1 1 1	0 0 0 0
	Satisfaction	TIME MATERIAL LABOUR PLANT	3 3 3 3	2 2 2 2	1 1 1 1	0 0 0 0
	Financial incentive	TIME MATERIAL LABOUR PLANT	3 3 3 3	2 2 2 2	1 1 1 1	0 0 0 0

	Fringe benefit	TIME MATERIAL LABOUR PLANT	3 3 3 3	2 2 2 2	1 1 1 1	0 0 0 0
	Foreman-craftsmen relationship	TIME MATERIAL LABOUR PLANT	3 3 3 3	2 2 2 2	1 1 1 1	0 0 0 0
	Peer relation	TIME MATERIAL LABOUR PLANT	3 3 3 3	2 2 2 2	1 1 1 1	0 0 0 0
	Absenteeism	TIME MATERIAL LABOUR PLANT	3 3 3 3	2 2 2 2	1 1 1 1	0 0 0 0

Thank for your co-operation,

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APPENDIX E

APPENDIX E

PRODUCTIVITY COMPARISON QUESTIONNAIRE OF SEVEN REGIONS OF INDONESIA

Introduction

The School of Construction Engineering and Technology, University of Woverhampton United Kingdom and University of Atma Jaya Yogyakarta, Indonesia are currently conducting a series of studies into construction productivity in Indonesia. The aim of these studies is to compare productivity problem in seven regions in Indonesia. This questionnaire is designed in a way that enable your valuable past experience contribute to this work. All answers will be treated in absolute confidence and used only for academic purpose. Your co-operation is highly appreciated.

Operative productivity of one region to another could be difference depends on level of the construction industry development of the regions. It is the objectives of this survey to investigate the deviation of the productivity problems amongst the regions. The nine variables under investigation are briefly defined as shown in Table E1.

Question Sample

The following deviation table sample (Table. E2) indicate an engineer who has experience working with operatives in the seven regions of Indonesia. Note that Yogyakarta is applied as a benchmark for this study. For instance, a bricklayer from Yogyakarta can lay 100 bricks in a unit time, How many brick can be laid by bricklayers from other regions ? In this example, Jakarta bricklayer can lay 120 bricks, West Java 20, Central Java 115, East Java 115, Western Region of Indonesia 95, and Eastern Region of Indonesia 80 bricks. Other example, If Yogyakarta worker is paid in 100 unit of money. For the same job, how much workers from other regions are paid ? In this regard, workers from Jakarta and West Java are highly paid.

Table E1. Description of Productivity Variables

Variables	Description
Production output	Quantity of work done over a period of time. i.e. m2/day, m3/day, ton/day
Time spent working productively	Hours devoted for productive work over the standard working hours. Productive work, for instance, of a bricklayer includes: spreading mortar, fetching mortar, fetching brick, cutting brick, laying brick, filling joints, measuring, setting and checking, and raking and pointing.
Craftsman motivation	Enthusiasm of workers in performing their job. This includes eagerness to stay on sites, ready for working overtime, return home once for a month.
Craftsman skill level	Ability to combine all necessary productive motions to achieve a standard output. The measurements include dexterity, construction education / training back ground, experience in construction work, accuracy in carrying out the work, and having initiative to work.
Craftsman remuneration	Amount of money (in Rupiah) received by a craftsman in standard working time.
Level of supervision	This is defined as to the extent of which foremen take care of quality of the works. This may includes planning for resources when needed, giving instructions, supervising the quality as well as quantity of works being undertaken. Generally, the better the supervision level, the smaller the amount of necessary rework.
Foreman motivation	Motivation is defined as the enthusiasm of workers in performing their job. These includes eagerness to stay on sites, ready for working overtime, return home once for a month.
Foreman remuneration	Amount of money (in Rupiah) received by a foreman in standard working time or a unit of work package.
Severity productivity problems	Problems include shortage of skilled labour locally, also associated with poor production output, lack of motivation. difficult to be led, and having a relative high wage.

Table E2 A Sample Answer Sheet of Productivity Related Variables in Seven Regions of Indonesia.

Construction Operatives' Productivity Related Variables	**Deviation Within the Regions**							**Remark**
	1	**2**	**3**	**4**	**5**	**6**	**7**	
Bricklayer production output	1.00	1.20	1.20	1.15	1.15	0.95	0.80	
Carpenter production output	1.00	1.20	1.20	1.20	1.15	0.90	0.75	
Steelfixer production output	1.00	1.20	1.20	1.15	1.20	0.90	0.75	
Craftsmen production output	1.00	1.20	1.20	1.18	1.16	0.92	0.76	
Time spent working	1.00	1.30	1.30	1.20	1.25	0.80	0.70	
Craftsmen motivation	1.00	1.50	1.40	1.30	1.25	0.80	0.70	
Craftsmen skill level	1.00	1.50	1.50	1.50	1.40	0.80	0.90	
Craftsmen remuneration	1.00	1.50	1.50	1.30	1.40	1.10	1.20	
Level of supervision	1.00	1.40	1.40	1.30	1.30	1.10	0.90	
Foremen motivation	1.00	1.50	1.50	1.30	1.40	1.60	1.60	
Foremen remuneration	1.00	1.50	1.40	1.45	1.35	0.80	0.75	
Severity productivity problems	1.00	0.80	0.70	0.95	0.90	1.40	1.50	

Note: 1, 2, 3, 4, 5, 6, and 7 represents Yogyakarta (as a benchmark), Jakarta, West Java, Central Java, East Java, Western region of Indonesia, and Eastern region of Indonesia respectively. The respondent has experience with operatives in all of these seven regions.

You could be qualified to fill this table if you have experience working with operative from Yogyakarta and at least with operatives from one of other regions.

Having understood the explanation of deviation table, you are request to fill the following table based on you past experience. Please indicate the difference of variable of productivity indicator from other region compare to Yogyakarta.

Table E3 A Questionnaire Sheet of Productivity Related Variables in Seven Regions of Indonesia.

Construction Operatives' Productivity Related Variables	Deviation Within the Regions							Remark
	1	2	3	4	5	6	7	
Bricklayer production output	1.00							
Carpenter production output	1.00							
Steelfixer production output	1.00							
Craftsmen production output	1.00							
Time spent working	1.00							
Craftsmen motivation	1.00							
Craftsmen skill level	1.00							
Craftsmen remuneration	1.00							
Level of supervision	1.00							
Foremen motivation	1.00							
Foremen remuneration	1.00							
Severity productivity problems	1.00							

APPENDIX F

APPENDIX F

BASIC STATISTICAL TESTS FOR EVALUATING PRODUCTIVITY PROBLEMS

Introduction

As a complement to questionnaire design, let us review some of the statistics scales / measurement and techniques applied in this study. They include:

1 scales / level of measurement as well as the classification of variables in the questions;

2 . analysis techniques.

Scale / Level of Measurement of the Data

An initial step is the measurement of the variables. Leedy (1989) describes measurement as the quantifying of phenomenon which results in a mathematical value. Measurement involves the comparison of the data being measured to a pre-established standard. The various scales or level of measurements in use are:

1) Nominal measurement which divides the data into discrete categories. Any data that can be differentiated merely by assigning a name to it falls in this level of measurement. Examples in construction project of this study include project title, location, type of function, etc.
2) Ordinal measurement which qualifies data or entity in terms of being of a higher or lower, greater or lesser order than a comparative entity but without specifying the size of the intervals. For a building, we can assign indicative sizes (greater or lesser, earlier or later, better or worse, etc.) to assessments of. Examples include severity of productivity problem, craftsmen skill, level of site management, etc.
3) Interval measurement is characterised by two features - equal units of measurement and an arbitrarily established zero point. It is distinguished from ordinal measure by having equal intervals between the units of measure, e.g. weight in kg, temperature in degree

centigrade. It is a qualitative scale. Its main shortcoming is that it does not have "true zero". This means that one cannot interpret a score of 50 as indicating twice as much a given trait as a score of 25. Characteristics of a building which fall into this category would be numerical ratings, if generally understood, for examples: unproductive time, production output, etc.

4) Ratio measurement which expresses values in terms of multiples and fractional parts. It has an absolute or true zero point which is the total absence of the quantity being measured. Any feature of a building can be grouped on a ratio level if it is measured in numerical, linear, superficial or cubic yards, time unit (e.g. hour), money unit (£, Rp) or weight (kg), etc. Examples include gross floor area, project duration, cost, etc.

Table G1 provides a summary of the relationship between non-numeric and numeric data of four scales of measurement. Nominal and ordinal scales can generate both non-numeric and numeric data, but that interval and ratio scales generate only numeric data (see Anderson, et.al, 1990)

Correlation Analysis

Relationships between sets of variables can be investigated by using correlation analysis such as Pearson product moment, Spearman rank order, and Chi square. In this study Spearman rank correlation analysis was employed to evaluate different rankings (significance of rankings, as well as degrees of agreement). The correlation coefficient ranges from 0 to 1 indicating that poor to good association respectively. The following equation is used to calculate Spearman Rank Correlation Coefficient:

$$r_s = 1 - \frac{6\sum d_i^2}{n(n^2-1)} \qquad \text{F1}$$

where n = the number of items or individual being ranked;

x_i = the rank of items i with respect to one variable;

y_i = the rank of item i with respect to a second variable;

$d_i = x_i - y_i$

Test for Significant Rank Correlation - As with many other statistical procedures, we may wish to use sample results to make an inference about the population rank correlation ρ_s between two variables. To make this inference, we must test the following hypotheses:

$$H_0: \rho_s = 0$$

$$H_a: \rho_s \neq 0$$

Under the null hypothesis of no rank correlation (ρ_s), the rankings are independent, and the sampling distribution of r_s is as follows:

Mean: $\mu_{rs} = 0$ F2

Standard Deviation:

$$\sigma_{rs} = \sqrt{\frac{1}{n-1}} \quad \text{.. F3}$$

Test statistics:

$$z = \frac{r_s - \mu_{rs}}{\sigma_{rs}} \quad \text{.. F4}$$

Analysis of Variance

As would be readily explained in statistical texts, the analysis of variance seeks to determine if differences between more than two means is due to chance or due to actual differences between the means. There should be basic normality assumption (use Shapiro Wilk or F-S Liliefors test) and equal variances (use Levene test) before conducting this analysis.

The null hypothesis is commonly stated that two means of the comparable groups (variables) are equal. If the significant test provided value (e.g. F probability) greater or equal to 0.05, then the null hypothesis is accepted. It can be concluded that the means the variables (however larger the difference) are not significantly different. Conversely, if F probability is smaller than 0.05, than null-hypothesis is rejected, therefore we may imply that the means of the comparable variables (however smaller the difference) are significantly different.

A significant F value tells us only that population means are probably not equal. It does not tell us which pairs of groups appears to have different means. We reject the null hypothesis that all population means are equal if any two means are unequal. We need to use special test called Multiple Comparison Procedures (MCP) to determine which means are significantly different from each other. One example of the MCPs is Bonferroni multiple comparison test. It adjusts the observed significance level based on the number of comparisons we are making. For example, if we are making 5 comparisons, the observed significance level for the original comparison must be less than 0.05/5 or 0.01, for the difference to be significant at 0.05 level. For further discussion on MCP technique, see Toothaker (1993). Chapters 3 and 6 applied ANOVA technique for data analysis.

One sample t-test

If factors of high influence are primary interest, one sample t-test is appropriate to be performed with null-hypothesis representing the mean score. This allows the identification of factors whose means are significantly higher than midpoint 'moderate'. In the case of that certain assumptions inherent in t-test, namely normality and randomness of the sample are not fully matched by the survey procedure and results, then the confident interval should be set higher, perhaps greater than 99% (see Reekers and Smithson, 1994). This technique was applied in Chapter 8 in comparative study of productivity problems in seven region in Indonesia.

Friedman Two-way Analysis of Variance by Ranks

When the data from k matched samples are in at least an ordinal scale, the *Friedman two way analysis of variance by ranks* is used to test the null hypothesis that k samples have been drawn from the same population. The Friedman test is used to compare two or more related samples. (This is an extension of the tests for paired data.) The k variables to be compared are ranked from 1 to *k* for each case, and the mean ranks for the variables are calculated and compared, resulting in a test static with approximately a Chi-square distribution.

Friedman Two-way of Anova by ranks is also suitable statistical technique for testing for the hypothesis on priority of factors. This is a measure of degree of association or agreement among sets of rankings (Siegel & Castellan, 1988). Since the null hypothesis is that the sets of rankings are independent or related, a rejection of the null hypothesis will imply that the respondents have some degree of consistency in their ranking of the factors. A 5% significant level is set for this test for analysis data in Chapters 5 and 6.

The Friedman test determines whether the rank totals (denoted Rj) for each condition or variable differ significantly from the values which would be expected by chance. To do this test, we compute the value of the statistic which we shall denote as F_r,

$$F_r = \left[\frac{12}{Nk(k+1)} \sum_{j=1}^{k} R_j^2 \right] - 3N(k+1) \qquad \text{F5}$$

Where N = number of subjects (rows)

k = number of variables or conditions (columns)

Rj = sum of ranks in the jth column (ie., the sum of ranks for the jth variable)

$\sum_{j=1}^{k}$ directs on to sum the squares of the sums of ranks over all conditions.

Probabilities associated with various values of F_r when H_0 is true have been tabulated for various sample sizes and various numbers of variables (see Siegel and Castellan, 1988). If the observed value of F_r is large than the tabled value of F_r at the chosen significance level, then H_0 may be rejected in favour of H_1.

Kendall Concordance Analysis

A suitable statistical technique for testing for the hypothesis on priority of factors is Kendall concordance analysis. The special feature of concordance test such as this is that, attention can be focused on the agreement between sets of ranks rather than their differences. This concept is extended to many variable instance where we are interested in the agreement between any number of sets of ranking. This concept is termed the evaluation of concordance (Siegel and Castellan, 1988).

The Kendall coefficient of concordance (*W*) is a measure of degree of association or agreement among sets of rankings (Siegel & Castellan, 1988). This is used to test the null hypothesis that the sets of rankings are independent or related. A rejection of the null hypothesis will imply that the respondents have some degree of consistency in their ranking of the factors. A 5% significant level is set for this test. Furthermore the coefficient of concordance (*W*) is used a measure how good an agreement (ranging from 0 to 1) has been achieved amongst the respondents. A coefficient of $W = 1$ indicates a perfect agreement and zero indicates no agreement amongst the respondents.

Calculating *W* - To evaluate *W*, the data is first arranged into $k \times n$ tables each row representing ranks assigned by a particular judge to n factors or aspects of a concept or problem. Table F1.1 illustrates the process.

Table F1.1 Calculating Kendall Concordance Coefficient

Ranks	Aspect of problems							
Judges	A_1	A_2	A_3	A_4	.	.	.	A_n
J_1	$R_{1.1}$	$R_{1.2}$	$R_{1.3}$	$R_{1.4}$	.	.	.	$R_{1.n}$
J_2	$R_{2.1}$	$R_{2.2}$	$R_{2.3}$	$R_{2.4}$	.	.	.	$R_{2.n}$
J_3	$R_{3.1}$	$R_{3.2}$	$R_{3.3}$	$R_{3.4}$	.	.	.	$R_{3.n}$
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
J_k	$R_{k.1}$	$R_{k.2}$	$R_{k.3}$	$R_{k.4}$	.	.	.	$R_{k.n}$

The coefficient of concordance is given by the following formula:

$$W = \frac{\sum_{i=1}^{n}(\overline{R}_i - \overline{R})^2}{n(n^2-1)/12} \quad \text{..F6}$$

Where k = the number of sets of ranking (e.g. the number of judgement);

n = the number of aspects of a problem or factor being ranked;

$\overline{R}$ = average of the ranks assigned to the i^{th} aspect of problems;

$n(n^2 - 1) / 12$ = the maximum possible squared deviations, i.e. the numerator which will occur if there were perfect agreement among k sets of ranks, and the average ranking were 1,2,3,...., n;

$\overline{R}_i$ = the rank assigned by an individual judge to one aspect of problem posed.

This statistic varies between 0 and 1 regardless the number of sets of rankings. The reason is that, where more than two sets of ranks are involved, the judges cannot disagree completely. For instance, if judge A and judge B are in disagreement and judge A is also in disagreement with judge C, then judge B and C must agree. In other words where two more judges are involved agreement and disagreement are not symmetrical opposites. The

Kendal's coefficient W, must be zero or positive. The numerator of formula is thus an index of the variability of the rankings. Where there is no consensus amongst the judges, the variability is zero i.e. the average rank will be the same for all aspects of a problem posed.

Testing Significance of *W* - If the number of judge is small than 7, Table F1.2. can be used to test the significance at various level. Where the number of judge k is greater than 7, Table F1.3 can be used. The Chi-square value for this statistics is given by:

$$X^2 = k(n-1)W \qquad \text{F7}$$

that is, approximately distributed as the Chi-square distribution with k-1 degrees of freedom. If the value of calculated Chi-square equals or exceed that shown by the X^2 distribution table for a particular level of significance and degree of freedom, then the null hypothesis that k sets of ranks are unrelated (independent) may be rejected.

Table F1.2. Critical values for the Kendall coefficient of concordance W*

	N = 3	
k	$\alpha = 0.05$	$\alpha = 0.01$
8	0.376	0.522
9	0.333	0.469
10	0.300	0.425
12	0.250	0.359
14	0.214	0.311
15	0.200	0.291
16	0.187	0.274
18	0.166	0.245
20	0.150	0.221

Table F1.2. Continued

k	N = 4		N = 5		N = 6		N = 7	
	α = 0.05	α = 0.01	α = 0.05	α = 0.01	α = 0.05	α = 0.01	α = 0.05	α = 0.01
3	-	-	0.716	0.840	0.660	0.780	0.624	0.737
4	0.619	0.768	0.552	0.683	0.512	0.629	0.484	0.592
5	0.501	0.644	0.449	0.571	0.417	0.524	0.395	0.491
6	0.421	0.553	0.378	0.489	0.351	0.448	0.333	0.419
8	0.318	0.429	0.287	0.379	0.267	0.347	0.253	0.324
10	0.256	0.351	0.231	0.309	0.215	0.282	0.204	0.263
15	0.171	0.240	0.155	0.211	0.145	0.193	0.137	0.179
20	0.129	0.182	0.117	0.160	0.109	0.146	0.103	0.136

Table F1.3. Critical value of the Chi-square distribution

DF	P = 0.05	P = 0.01	DF	P = 0.05	P = 0.01
1	3.84	6.64	16	26.30	32.00
2	5.99	9.21	17	27.59	33.41
3	7.82	11.34	18	28.87	34.80
4	9.49	13.25	19	30.14	36.10
5	11.07	15.00	20	31.41	37.57
6	12.59	16.81	21	32.67	38.93
7	14.07	18.48	22	33.92	40.29
8	15.51	20.09	23	35.17	41.64
9	16.92	21.67	24	36.42	42.98
10	18.31	23.21	25	37.65	44.31
11	19.68	24.72	26	38.88	45.64
12	21.03	26.22	27	40.11	46.96
13	22.36	27.69	28	41.34	48.28
14	23.68	29.14	29	42.56	49.59
15	25.00	30.58	30	43.77	50.89

Source: Siegel and Castellan, (1988)

Interpreting W - A high significant value of W can be interpreted as meaning that k respondents to a question are apply essentially the same standard in rating the n aspect of a problems under study. Their pooled ordering (ranking) can be used as a criteria or standard, especially where there is no known ordering of particular objects. Siegel and Castellan (1988) discuss the use of this statistics in detail.

Kendall (1970) however, suggested that the best estimate of the true ranking of n objects is provided where W is significant by the order of various sum of ranks. If one accepts the criteria used by the judges (evidenced by the magnitude and significance of W). then the best true ranking is provided by average of the ranks. This implies that the most important factor or aspect of a problem is the highest ranking one.

Interpreting Results of this Survey - For example project managers were asked to indicated the reason for employing sub-contractors.

From Table F1.4, grand mean $\overline{R}$ can be calculated 3.50. To obtain the numerator of W in equation F6, the square of deviation of each average rank from the mean value is obtained and summed.

$$\sum_{i=1}^{n}(\overline{R}_i - \overline{R})^2 =$$

$$(3.74\text{-}3.50)^2 + (4.67\text{-}3.50)^2 + (3.97\text{-}3.50)^2 + (3.78\text{-}3.50)^2 + (2.43\text{-}3.50)^2 + (2.41\text{-}3.50)^2 = 4.0588$$

Since n = 6, the value of the coefficient of concordance from Table F1.2 using equation F6:

$$W = 4.0588 / \{6(6^2 - 1) / 12\} = 0.23$$

W = 0.23 expresses the degree of agreement amongst the 29 Project managers in rating the reason they cite for employing sub-contractors. Using equation F7 the Chi-square value is given by:

$$X^2 = 29(6-1)\ 0.23 = 33.35$$

Referring to the critical values of Chi-square distribution table with a degree of freedom (DF):

$$DF = n - 1 = 6 - 1 = 5$$

Table F1.4. Project Managers' Priority Ranking.

	Reduce workload	Increase profit	More productive	Reduce financial risk	No expertise from contractor	Skilled trades no available
1	5	4	2	3	6	1
2	6	2	2	2	4	5
3	1	2.5	5.5	2.5	4	5.5
4	2.5	4	2.5	6	1	5
5	5	6	1	4	2	3
6	4	6	1	5	2.5	2.5
7	6	5	1	4	3	2
8	3	5	4	6	2	1
9	4	6	5	3	1.5	1.5
10	4	6	3	5	1	2
11	1	2	6	4	5	3
12	4	6	5	1	2	3
13	5	6	4	2	3	1
14	4	2	5	3	6	1
15	2	4	6	5	1	3
16	5	4	6	3	2	1
17	1	6	5	4	2.5	2.5
18	6	5	4	3	1.5	1.5
19	6	1	4	5	3	2
20	4	6	3	5	1	2
21	1	6	4	5	3	2
22	4	5	6	3	2	1
23	3	4	6	5	1.5	1.5
24	3	6	4	5	1.5	1.5
25	5	6	4	3	1	2
26	4	3	6	1	2	5
27	4	5	6	3	1.5	1.5
28	1	6	2	5	3	4
29	5	6	2	4	1	3
Sum	108.50	135.50	115.00	109.50	70.50	70.00
Mean	3.74	4.67	3.97	3.78	2.43	2.41

The critical value of X^2 is less than the observed value and has a probability of occurrence under H_0 of $p < 0.001$ (see Table F1.5). We can conclude with confidence that level of agreement amongst the PMs is higher that it would be by chance had their rating been random or independent. The very low probability under null hypothesis associated with observed value of *W* allows the rejection of H_0 that rating of the PMs are unrelated to each other and conclude that there is some consensus although small among the PMs concerning the reason for employing sub-contractor.

Table F1.5. Project Managers' Priority Ranking of Reasons for Employing Sub-contractor.

Reasons for Employing Sub-contractor	Mean Rank
Skilled trades not available	2.41
No expertise from main contractor	2.43
Reduce work load	3.74
Reduce financial risk	3.78
More productive	3.97
Increase profit	4.67

Cases	W	chi-square	D.F.	Significance
29	0.23	34.01	5	0.0000

Multiple Regression Analysis

The correlational approach which is very germane to hypothesis testing on multivariate relationship is the multiple regression technique. Regression analysis works best with variables on the interval and ratio scales i.e. quantitative variables. However, qualitative variables on the nominal and ordinal scales can be represented as "dummy" or "indicators" variables. A dummy variable denotes the presence or absence of qualitative feature by 1 or 0 respectively. Indicator variables can be includes in a regression analysis.

Establishing relationships or associations among a number of variables may not always be a straight forward exercise. Productivity problem is a complex process and no ad hoc selection of factors will suffice to completely explain the variability of severity productivity among a number of the projects. Nevertheless, it is possible to attempt to identify a comparative few variables which explain or account for a significant proportion of variability of severity of productivity problem in seven regions of Indonesia for instance, through applying regression analysis.

Multiple regression model applied for data analysis in Chapter 8 is as follows:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_p x_p + \varepsilon \qquad \text{F8}$$

where y is dependent variable;
$x_1, x_2, \ldots x_p$ are independent variables;
$\beta_1, \beta_2, \ldots \beta_p$ are partial (or regression) coefficient of multiple regression equation;
ε is residual with mean or expected value of zero; that is $E(\varepsilon) = 0$.

The multiple regression model produces two piece of information that are useful to analysing relationships between independent variables and a single dependent variable. The are regression coefficient β and the amount of variation in the dependent variable explained by the model independent variables. This latter value is called coefficient of termination (R^2), also known as 'goodness of fit'.

In two independent variable case, the unbiased estimate of the regression coefficient would be summarised as followed:

$$\beta_1 = \left(\frac{S_y}{S_{x_1}}\right) \frac{r_{yx_1} - r_{yx_2} r_{x_1 x_2}}{1 - \left(r_{x_1 x_2}\right)^2} \qquad \text{F9}$$

$$\beta_2 = \left(\frac{S_y}{S_{x_2}}\right)\frac{r_{yx_2} - r_{yx_1} r_{x_1x_2}}{1-\left(r_{x_1x_2}\right)} \qquad \text{...F10}$$

where s is the standard deviation of variables x_1, and x_2 or y; and r is the zero-order of pairwise correlation between any two of the variables. The zero order correlation between two variables is defined as the co-variance between them divided by the product of their respective standard deviations. This is represented by formula shown below:

$$r_{xy} = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})/(N-1)}{s_y s_x} \qquad \text{...F11}$$

where x_i is the ith observation of variable x; $\bar{x}$ is the mean of variable x; y_i is the ith observation of variable y; $\bar{y}$ is the mean of variable y; N is the sample size; and s_x and s_y are standard deviation for variable x and y respectively.

The explained variation in a regression model represents the total sums of squares less the error sums of squares divided by total sums of squares. In the bivariate case the coefficient of the determination is presented as:

$$R^2 = \frac{\sum(y_i - \bar{y})^2(y_i - \bar{y})^2}{\sum(y_i - \bar{y})^2} \qquad \text{...F12}$$

The numerator of the above equation is called the sum of square due to regression. In multiple regression case, the coefficient of determination would be the same, that is, the sums of squares due to regression divided by total sums of squares. This value will always be the same as or larger than bivariate case, because adding independent variables hopefully will explain additional variation in the dependent variable.

There are 5 important assumptions associated with regression that must be met to produce reliable results. They are:

1) Error term is normally distributed random variable taking on positive or negative values to reflect the deviations between the dependent variable and the independent variables in the model.
2) The relationship between dependent and independent variables approximates a linear function.
3) The error term has a constant variance (i.e., homoscedasticity) regardless of the values of independent variables.
4) The error term has a mean or expected value of zero.
5) The value of error term are independent.

The regression model will be used to test the study hypotheses, that is, to examine the relation severity of the productivity problem and several independent variables such as 'lack of material', ' rework', 'absenteeism', and so on. These relationship may or may not be considered statistically significant. Two basic tests of statistical significance will be performed. First, a goodness of fit test determines whether or not the model with its independent variables is significant predictor of dependent variable. The statistic for the amount of variation in dependent variable explained by the independent variables in the regression equation. It takes on an F-distribution and, therefore, it is tested for statistical significance using the F-statistic. The null hypothesis for this significance test is portrayed as follows:

Null Hypothesis - H_0 :ρ^2 is equal to zero

Alternative Hypothesis - H_1: ρ^2 is not equal to zero

where ρ^2 is the population variance explained by the model and is estimated by the regression coefficient of determination, R^2. The F-statistics is calculated by comparing the ratio of the regression sums of squares adjusted for its degree of freedom to the error sums of squares adjusted for its degree of freedom. Computationally, the formula is:

$$F_{k\_N-k-1} = \frac{R^2 / k}{1 - R^2 / (N - k - 1)} \quad \text{F13}$$

where R^2 is the multiple regression coefficient of determination; N is the sample size, and k is the number of independent variables in the model. The calculated value of the F-statistic, is then compared to the F-critical value taken from F-distribution with k degree of freedom in the numerator and N-k-1 degrees of freedom in denominator. If the F-statistic is greater than F-critical value, then R^2 is statistically significant, or different from zero, that is, the null hypothesis can be rejected. It can then be concluded that independent variables in the model account for a portion of dependent variables' variation.

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APPENDIX G

1. THE MANUAL OF

   CONSTRUCTION PRODUCTIVITY AUDIT SYSTEM (CONPAS).

2. CREATING EXPERT SYSTEM USING VP-EXPERT - AN EXAMPLE .

3. LIST OF PROGRAMME.

1. THE MANUAL

USER'S GUIDE FOR RUNNING THE PRODUCTIVITY AUDIT SYSTEM

Minimum Hardware Requirements

System Unit	IBM PC or Compatible 2 MK RAM Mouse
Disk Drive	One floppy disk drive. (A hard disk is preferred)
Monitor	Colour/graphic display
Printer	Quarto size

Software Requirements

Environment	DOS 2.0 or higher
Expert System Shell	VP-Expert

Files of the System

Name of Files	**Identification of the productivity problem (Primary level)**
PROBLEM1.KBS	Identification of material problems
PROBLEM2.KBS	Identification of rework problems
PROBLEM3.KBS	Identification of worker interference problems
PROBLEM4.KBS	Identification of absenteeism problems
PROBLEM5.KBS	Identification of equipment and tools problems
PROPROS.KBS	Programme to introduce user for consultation
PROPROS1.KBS	Programme of user interface for detailed consultation.
PROPROS2.KBS	Programme of user interface for consultation on regional productivity problems.
PROPRO1.TXT	Guideline for resolving the problems
IDEN	A temporary working file to collect the data during running this module.
DEVIA.DBF	Data base file containing deviation table for seven region of Indonesia with Yogyakarta as benchmark.

Module Method and Technology	**Identification of factor for improving on-site productivity (Optimisation level)**
Name of Files:	
METHOD1.KBS	Identification of need for the further improvement of engineering design.
METHOD2.KBS	Identification of need for the further improvement of
METHOD3.KBS	Identification of need for the further improvement of
METHODBS.KBS	Programme of user interface for detailed consultation.
BSMETHOD.TXT	Best practices for improving engineering design.
METHOD	A temporary working file to collect the data during running this module.

Module Site Management	**Identification of factor for improving on-site productivity (Optimisation level)**
Name of Files:	
SITE1.KBS	Identification of need for the further improvement of planning and scheduling
SITE2.KBS	Identification of need for the further improvement of site layout.
SITE3.KBS	Identification of need for the further improvement of site communication.
SITE4.KBS	Identification of need for the further improvement of manpower management
SITEBS.KBS	Programme of user interface for detailed consultation.
BSSITE.TXT	Best practices for improving site management.
SITE	A temporary working file to collect the data during running this module.

Module Working Environment	**Identification of factor for improving on-site productivity (Optimisation level)**
Name of Files:	
ENVI1.KBS	Identification of need for the further improvement of supervision quality.
ENVI2.KBS	Identification of need for the further improvement of safety.

ENVI3.KBS	Identification of need for the further improvement of employment condition.
ENVIBS.KBS	Programme of user interface for detailed consultation.
BSENVI.TXT	Best practices for improving working environment.
ENVIRON	A temporary working file to collect the data during running this module.

Module Human Factors	**Identification of factor for improving on-site**
Name of Files:	**productivity (Optimisation level)**
HUMAN1.KBS	Identification of need for the further improvement of pay related issues
HUMAN2.KBS	Identification of need for the further improvement of teamwork
HUMANBS.KBS	Programme of user interface for detailed consultation.
BSHUMAN.TXT	Best practices for improving human factors.
HUMAN	A temporary working file to collect the data during running this module.

Installation

Install the VP Expert in C (or other specified part of hard disk). For VP expert installation, copy VP Expert disk to a specified sub directory.

```
C:\md VPX
C:\cd VPX
C:\VPX\copy: a:\*.*
```

Now VP Expert shell has been installed in sub directory VPX at drive C.

Running the Audit System

Go to C drive and sub directory VPX, and then type VPX again. You will soon get the main menu of the VP Expert.

Insert IMPROVE Version 3.0 into disk drive A

Go to Path using arrow key or type F7 and press ENTER.
Type A: and all the files which have KBS extension will appears on the screen.
Using arrow key to highlight PROBLEM1, and press ENTER.
Use arrow key for going to CONSULT and press ENTER or press F4 key.
Now, you are running the system.
Just follow all instruction supplied by the system.

Maintainability of the Programme

Since the programme consisted of modular system, it is easy to maintain if addition predominant factor(s) is(are) found to be included in the productivity audit system. Using EDIT or F3 of the main VP-Expert menu, an individual knowledge base file (with KBS extension) is easy to modify.

The best practices currently collected from survey of literature, and interviews with experts can be improved through future finding. For future improvement of best practices, the five text files of the system (PROPROS1.TXT; BSMETHOD.TXT; BSSITE.TXT; BSENVI.TXT; and BSHUMAN.TXT) can be improved using text editor from DOS, or other word processing packages.

2. CREATING EXPERT SYSTEM USING VP-EXPERT

Introduction

The objective of this appendix is to explain how to create an expert system using VP-Expert. Example is given through explanation of development of a module of Construction Productivity Audit System (CONPAS). The module called "PROPRO" is a diagnostic approach to investigate productivity problem on construction site. It consists of 6 knowledge bases that are linked as a unit.

To use VP-Expert, a knowledge base must be prepared. VP-Expert is capable of transferring the entire knowledge base into the shell directly using VP-Expert rule editor. It is important to represent the knowledge bases with a plain English for PROPRO. The knowledge bases have been acquired from industry experts through an extensive research on Indonesia high-rise construction.

Preliminary Steps

The VP-Expert software can be transferred to a PC fixed disk by following the instruction in the Introduction section of VP Expert User's Manual. A procedure similar to what is explained in User's Manual is summarised as follows:

<u>Transferring VP-Expert and sample programs to a fixed disk</u>

Create a sub directory with the name EXPERT if it does not already exist:

C:\>MD C:\EXPERT

Transfer the contents of VP Expert diskette to the EXPERT sub directory:

C:\>A:

A:\>COPY*.* C:\EXPERT

Repeat the procedure to copy 'PROPRO' programmes and data files to the same directory. There are six files on the VP Expert diskette in a sub directory named PROBLEM1 to PROBLEMS5, and PROPROS (programme connecting productivity problems to consultation on solution of the problems).

Starting the VP-Expert software

Go to the EXPERT sub directory:

C:>CD\EXPERT

Type the command VPX to start the programme:

C:\EXPERT VPX

Note that the main menu option appear, with the menu option *Edit* highlighted. If the computer does not have a fixed disk, consult the instruction in VP-Expert User's Manual. Note VP-Expert require 384K RAM.

VP-Expert Programming

All VP-Expert programmes consist of three sections: an ACTION block, a set of STATEMENTS, and a set of RULES. The order in which the three sections appear is not important, but ACTIONs block normally appears at the beginning of the programme.

In general, expert system solve problem using either forward or backward chaining inference strategy (see Bell and Elzarka, 1992). VP-Expert uses a backward chaining search strategy. The backward chaining strategy is best demonstrated by examining the order in which rules are fired using a consultation trace that is available in VP-Expert. The inference engine starts with rules that assign values to the goal variable listed in the first

FIND statement in ACTION block. Other rules are then examined, as necessary, until the rule that contained the goal variable is either fired or rejected. If more than one rule assigns a value to the goal variable, then those rules are executed in the order in which they appear in the knowledge base.

ACTION Block

ACTION block begins with the keyword ACTIONS, followed by various clauses, and then with a semicolon. The clauses in ACTION block are executed in the order they appear to control programme execution. The FIND clause in the ACTION block directs the programme to find a value for the goal variable attached to the keyword FIND. Other keywords utilised in ACTION blocks i.e. DISPLAY, ENDOFF, PLURAL, etc.

The DISPLAY clause is frequently used in ACTION block to display messages and to display the value of goal variable(s). Using a tilde (~) character in a DISPLAY clause pauses the consultation until the user presses any key. DISPLAY clauses can also attached to the THEN portion of a rule (IF-THEN-DISPLAY).

The ENDOFF statement permits the selection of menu choices using only the cursor and enter keys. Finalising a selection with the end key is not necessary, unless a confidence factor is being assigned.

The PLURAL statement is always followed by a variable or variables meaning that more than one problem can be identified if appropriate. When the choices for the variable(s) are displayed during a consultation, any number of choices can be selected.

Using Text Files

A useful expert system feature is the ability to print lengthy text files as part of user consultation. The expert system may provide advice in the form of instructions to user. VP-Expert can access test files only if they have been converted to ASCII file (also called

DOS file) format. Most word processing programme are capable of creating and accepting ASCII files as a way of improving data transfer between various software packages.

In the example shown in Table G1, the expert system is being developed to provide advice pertaining to the solution of productivity problems on construction site. The consultation may provide general printed information as background information to make certain the user understands the concepts and terminology used in the information pertaining to specific recommendations generated as part of the consultation, i.e., it is suggested that the user check transportation facility for material handling, improve material requirement planning, improve material delivery on a proper places, etc. to solve material unavailability problems.

Linking VP-Expert Programmes using CHAIN, SAVEFACTS and LOADFACTS Clauses

It is frequently advantageous to link two or more expert systems programmes together. Large knowledge bases cannot be manipulated unless the computer has sufficient memory. Thus breaking large problem into distinct separate small knowledge bases to facilitate debugging and maintaining purposes is important.

The VP Expert CHAIN clause accomplishes the programme linking process. A CHAIN clause in the ACTIONS block of the first programme can be used to reference the second programme to be executed. However, before loading and executing the second programme, the values of all variables computed in the first programme must be transferred to a text file using SAVEFACTS clause.

The second programme then loads the values of the variables computed during a consultation with the first program using the LOADFACTS clause in the ACTIONS block. If a third programme is to be executed, the second programme saves its data using SAVEFACTS and so on.

Mathematics Function

In addition to four basic arithmetic operations - addition, subtraction, multiplication, and division - ten mathematical functions can be used in a VP-Expert knowledge base. These include four arithmetic's and six basic trigonometric functions. The mathematical operations can be used in a knowledge base to specify values in rule condition, or to specify values in expression that assign a value to a variable. For example, take a look at Table G1 and G2. The mathematical functions are utilised in ACTION block.

Other Clauses

Statement after an exclamation mark (!) in RUNTIME block contents information that would not be executed during consultation. It is used as a note for the programmer.

RUNTIME - Placing this one-word statement anywhere in the knowledge base eliminates the two bottom windows during a VP-Expert consultation. This statement should be added to a knowledge base when development is finished and knowledge base is ready for end user.

EXECUTE - This statement causes a consultation to begin automatically upon execution of the Main Menu Consult command. When this statement is not present in a knowledge base, the user is required to give an additional command (Go) to start a consultation.

ENDOFF - Placing this one-word statement anywhere in the knowledge base eliminates the need to press [End] to finalise a MENU or CHOICES menu selection for a singled-value variable. (Menus for plural variables are not *affected). To make* a menu choices, the user simply needs to move the light bar to an option and press [Enter].

BKCOLOR - When this statement is included in a knowledge base, it sets the *background* display to the colour corresponding to the given number. The integer values (0, 1, 2, 3, 4, 5, 6, and 7) and their corresponding colours are black, blue, green, light blue, red, magenta, brown, and white respectively.

COLOR - This clause is used to change test colour on colour monitors. It can also be used to display blinking text. There are 16 colours available in VP Expert for both normal and blinking colours (see VP Expert Manual page 9-35).

CLS - The CLS clause clears the consultation window. In a non-runtime (three-window) consultation, the two bottom windows are not affected. If there are text windows open on the consultation screen, the CLS clause will clear only the ACTIVE window (the window indicated in the last ACTIVE clause).

Table G1. Examples of ACTION Block of a Knowledge Base.

```
!PROBLEM1.KBS
RUNTIME;
EXECUTE;
ENDOFF;
BKCOLOR=1;
ACTIONS
  COLOR=15
  CLS

  DISPLAY"

==========================================================================
                              CONPAS
                  CONstruction Productivity Audit System

     WELCOME TO THE PRODUCTIVITY PROBLEM IDENTIFICATION
                              PROGRAM

                       Designed and written by
                           Peter F Kaming

          School of CONstruction, Engineering and Technology,
             University of Wolverhampton, United Kingdom
                                and
   Faculty of Engineering, University of Atma Jaya Yogyakarta, Indonesia


==========================================================================

               [Press any key to continue]~"

CLS
DISPLAY"

     This programme is designed to aid the project manager in
     identification of productivity problems at a primary level. It
     includes identification of;
     1. Materials Management Problems
     2. Rework Problems
     3. Worker Interference
     4. Absenteeism
     5. Tools and Equipment Management Problems.


              [Press any key to continue]~"
CLS
```

Table G1. Continued

```
  DISPLAY"

          IDENTIFYING MATERIALS MANAGEMENT PROBLEMS


                    [Press any key to continue]~"

CLS

 FIND SEVERE11
    SEVERE111=(SEVERE11/5)
 FIND SEVERE12
    SEVERE121=(SEVERE12/5)
 FIND SEVERE13
    SEVERE131=(SEVERE13/5)
 FIND SEVERE14
    SEVERE141=(SEVERE14/5)
  SEVERE1 =((SEVERE11+SEVERE12+SEVERE13+SEVERE14)/20)
  DISPLAY "
The severity of material management problem is            {SEVERE1}

The severity of material management problem with respect
to
- on-site transportation difficulty is                     {SEVERE111}
- excessive paper work for material requisition is         {SEVERE121}
- material storage and proper delivery is                  {SEVERE131}
- material requirement planning is                         {SEVERE141}
"
  DISPLAY "
      The severity of the problem is indicated by an index:
      ranging from 1 (very severe problem) to; 0 (no problem at all)."


  DISPLAY "

          Press any key to continue~"



SAVEFACTS IDEN
CHAIN PROBLEM2
;
```

STATEMENT Sets

Each statement in the set of STATEMENTS (ASK, CHOICES, etc.) begins with keyword and concludes with a semicolon.

Table G2. Example of STATEMENT Sets of a Knowledge Base

```
ASK on_site: "How would you describe your problems encountered with
respect to on-site transportation difficulty?";
CHOICES on_site: high, medium, low;

ASK paper: "How would you describe your problem encountered with
respect to excessive paper work for material requisition?";
CHOICES paper: high, medium, low;

ASK deliver: "How would you describe your problem encountered with
respect to material storage and proper delivery?";
CHOICES deliver: high, medium, low;

ASK plan: "How would you describe your problem encountered with
respect to material requirement planning (including considering
supplier delivery)?";
CHOICES plan: high, medium, low;
```

RULE Sets

VP Expert programme rules have numbers, or names, followed by an IF portion, a THEN portion, and a concluding semicolon. More than one condition can be linked following the IF using either the AND keyword, or the OR keyword. More than one cause may appear following the THEN keyword. Other important keyword in STATEMENT set is BECAUSE which can be utilised to provide explanation / information if user makes enquiry when he/she runs the system. During consultation, the user can invoke WHY or How menu options to determine why a question is being asked, or how a value was assigned to a variable. These ACTIONs will display text attached to the rule that causes the question to be asked (WHY) or the rule that assigned the value to the variable (HOW). The text is attached to the rule using the BECAUSE option. It is important to note that the rules are not executed in order in which they appear in the programme. The order is controlled by a backward chaining strategy.

Table G3. Example of RULE sets of a Knowledge Base.

```
RULE 11
IF  on_site = high
THEN SEVERE11 = (5)
BECAUSE "
On-site transportation is often cited as being the major problem
associated with material availability, especially on congested high-rise
CONstruction project. Local transportation problem can be due to a lack of
capacity of equipment such as cranes or hoists.";

RULE 12
IF on_site = medium
THEN SEVERE11 = (3);

RULE 13
IF on_site = low
THEN SEVERE11 = (1);

RULE 21
IF  paper = high
THEN SEVERE12 = (5);

RULE 22
IF paper = medium
THEN SEVERE12 = (3);

RULE 23
IF paper = low
THEN SEVERE12 = (1);

RULE 31
IF  deliver = high
THEN SEVERE13 = (5);

RULE 32
IF deliver = medium
THEN SEVERE13 = (3);

RULE 33
IF deliver = low
THEN SEVERE13 = (1);
```

Table G3. Continued

```
RULE 41
IF  plan = high
THEN SEVERE14 = (5);

RULE 42
IF plan = medium
THEN SEVERE14 = (3);

RULE 43
IF plan = low
THEN SEVERE14 = (1);
```

Running a Consultation

Running a consultation is a way of executing an expert system computer programme for the purpose of extracting the knowledge contained in the programme. The sample programme PROPRO contains six knowledge bases that may apply to the process of diagnosing on-site productivity problems on high-rise construction.

From the VP-Expert main menu screen, press enter with consult option highlighted. A menu choices will appear. Position the light bar over the programme PROBLEM1 and press [Enter]. The welcome and the introduction text will appear on the screen. Then follow the instruction on the screen and answer the multiple choice questions. The first problem encountered with on-site productivity is 'Material Unavailability'. This diagnosis process will be completed after the user answering five questions, then the programme proceeds to the next problem (PROBLEM2).

Since the programme PROBLEM1 has been connected to PROBLEM2, the process of diagnosis would not be interfered by means of having to go back to main menu (see Table G1). PROBLEM2 consist of four questions concerning the severity of 'reworks' problems on construction site. The diagnosing process would continue to the end of 'PROBLEM5'. The conclusion would be displayed on the screen and it can be printed out. The diagnosis process proceed to consultation session on how to solve the problems especially emphasising on the most severe problems indicated by high value of indices (1 = very severe to 0 = not problem at all).

Using hypertext available in VP-Expert, the consultation can be applied using mouse. Clicking the topic that the user wants to consult, the suggestion of the solution of the problem will appear on the screen. After completing the consultation, user may proceed to further on-site productivity improvement programme or quit it by clicking the button [CONSULT].

Testing the Programme

Once the expert system has been developed, some tasks must be performed to insure that the system is performing correctly. Testing or verification, is the process of making certain the inference mechanism, or programme code, is executing properly. For example, conflicting, incomplete, or dead end rules must be eliminated. In developing CONPAS, verification is carried out by inviting project managers to run the prototype and if programme contains missing rules. They were used to check the individual modules as well as the whole system.

Validation, on the other hand, is securing assurance that the system is performing at an acceptable level of expertise and therefore satisfying the user's needs. In short, we need to determine if the given advice / recommendation is correct. The validation process of CONPAS using advice on how on-site productivity can be improved using best practices that have been extracted from experts in European Construction (see European Construction Institute, 1994) and adjusted to be useful for developing countries for example, Indonesia. Several senior project managers from Indonesian contractors collaborated in the validation process by running the prototype. Their critics on assumptions, detailed solution, and recommendation given by the system were incorporated in the final version of CONPAS.